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EVIDENCE BASE ON THE IMPACT OF INNOVATION PARTNERSHIP

PLENARY SESSION

MAKING THE MOST OF OUR LAND: MEETING SUPPLY AND DEMAND OF SOIL FUNCTIONS ACROSS SPATIAL SCALES

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Abstract. *The challenges of achieving both food security and sustainability have resulted in a confluence of demands on land within the European Union: we expect our land to provide food, purify water, sequester carbon, and provide a home to biodiversity and to external nutrients. All soils perform all these five functions, but some soils 'are better at' supplying selective functions. Functional Land Management is a framework for policy making aimed at meeting these demands by incentivising soil management and land use practices that selectively augment specific soil functions, where required. In this paper, we explore how the demands for contrasting soil functions, as framed by EU policies, may apply to very different spatial scales, from farm scale to national scale. At the same time, we show that the supply of each soil function is largely defined by local soil and land use conditions, with large variations at both local and regional level. We demonstrate that this has implications for soil management. While some soil functions must be managed at local (i.e. farm) level, others may be offset between regions with a view to solely meeting national targets. We review the policy instruments available to address the challenge of maximising the delivery of soil functions across these spatial scales, and bring these instruments together in a coherent policy framework.*

Key words: *Functional Land Management, sustainable intensification.*

INTRODUCTION

In autumn 2014, the UN revised its projections for population growth: the world's population is no longer expected to stabilise after 2050, but is now forecast to continue to grow and approach 11 billion people by 2100 [1]. These new figures will certainly fuel the debate whether the world is 'running out of land'. Because not only do we expect the world's agricultural land to provide a nutritious diet for all, we also expect it to provide clean water, to store carbon, recycle our waste and provide a home for biodiversity [2]. These competing demands have now brought soil science sharply back into focus. If we are to make the most of our land, we need to understand soils, as the 'engine room' of agriculture, in all their diversity.

Recognising the finite nature of soils, the European Commission published the EU Thematic Strategy on Soils in 2006 [3], which outlined the suite of functions that soils perform for humankind, as well as the threats to this functionality. The subsequent proposed Soil Framework Directive built on the concept of threats to soil quality and proposed actions to mitigate against these. This exclusive focus on soil quality as an 'intrinsic value' worthy of protection led to resistance from stakeholders, including the farming community, which ultimately resulted in the withdrawal of the proposed Directive in 2014 as part of the EU REFIT initiative [4].

However, these developments have not taken from the urgent need to explore how we can safeguard our land resource for the provision of food and ecosystem services [5]. In 2014, we proposed 'Functional Land Management' as a more utilitarian framework aimed at optimising the delivery of the five main soil functions [2]:

1) Primary productivity: the provision of food, feed, fibre and fuel.
2) Water purification and regulation: the ability of soils to purify water, for human consumption and maintenance of ecosystem integrity.
3) Carbon storage and regulation: the ability of soils to store carbon, with dual benefits, i.e. a) partial offsetting of greenhouse gas emissions and b) regulation of biological and physical soil processes.
4) Provision of a habitat for biodiversity, both below-ground and above ground diversity.
5) Recycling and provision of nutrients, specifically the ability of soils to provide a sustainable home for external nutrients such as those derived from landless farming systems (e.g. pig and poultry farms), as well as sewage sludge.

Source: Schulte et al. (2014)

Figure 1. **The five soil functions: white = primary productivity; blue = water purification; grey = carbon sequestration; green = provision of habitat; purple = nutrient cycling.**

In principle, all soils perform all of these functions, but some soils 'are better' at some functions than others. The relative suite of functions depends primarily on land use and soil properties. In Atlantic climates, soil drainage is the dominant driver of processes that define the functionality of soils [6]. These interdependencies were explored in detail by Coyle *et al*. [7], who propose the following matrix:

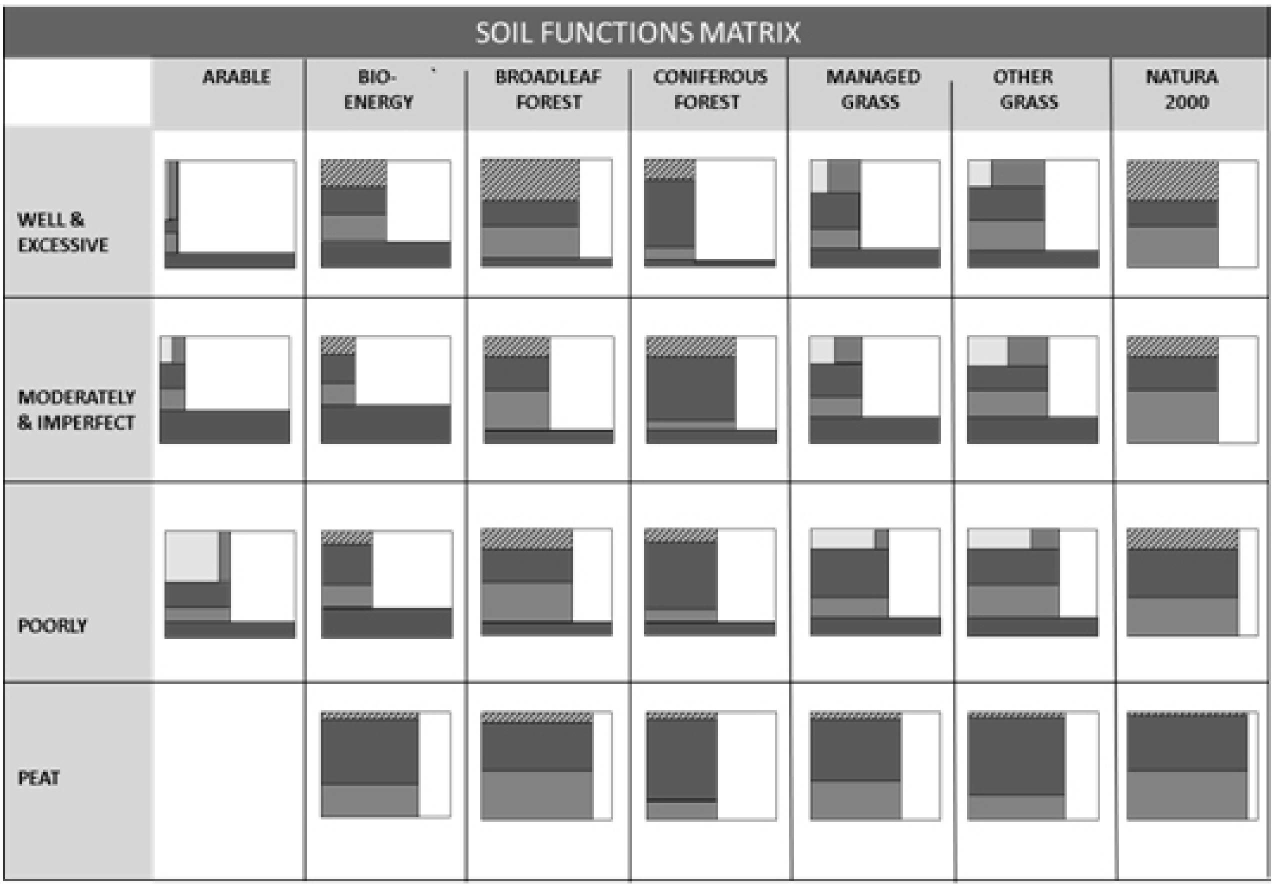

Figure 2. **Soil Functions Matrix for Atlantic Climates, as developed by Coyle *et al*. (under review).** Legend as per Figure 1.

A key element of Functional Land Management is that it does not necessarily aim to maximise all functions on all soils and land uses. This may be difficult to achieve, given the antagonistic interactions that may emerge, for example between primary productivity and biodiversity. Instead, Functional Land Management aims to meet the demand for each of the soil functions by selectively enhancing individual soil functions. For example, the need to increase the function 'Water Purification' may vary between soils or locations. Where there is no need to augment this function (i.e. in areas where water quality standards are already met), it may be more prudent to focus on one or more of the other functions.

In this paper, we examine in further detail how the supply of soil functions can be managed to meet the multitude of demands, as framed by European policies. We explain that it is imperative to consider the spatial scale to which each of the demands apply, which may vary from farm scale to national scale. Finally, we propose a framework for policy making that connects decision making across these scales.

MATERIALS AND METHODS

In this paper, we explore the spatial scale of both the demand for the five soil functions and the supply of these functions. We conducted a literature review to frame the demand for soil functions, as defined by European policies. We used mapping techniques to quantify the supply of soil functions, using Ireland as an example. This was based on the new 3rd generation Soil Map of Ireland [8]. The associated new Irish soil classification system allowed, for the first time, for the production of soil attributes maps, including the new indicative soil drainage map [9]. At the same time, we developed the first comprehensive Land Use map of Ireland, by combining and harmonising multiple partial datasets on land use [10]. For this paper, we intersected the indicative drainage map with the land use map, to derive a map of land use x drainage combinations, equivalent to those used in Figure 2 above.

Subsequently, for each of the five functions, we assigned a relative weighting to each land use x drainage category combination, based on the relative proportionalities of Figure 2. For functions 1-4, this weighting was normalised on a scale from 1-10, with 1 and 10 assigned to the land use x drainage combination with the lowest and highest capacity to supply this function, respectively. For function 5 (nutrient cycling), this weighting was normalised on a scale from 0-10 instead, because there are soils (notably peat soils) that cannot sustainably perform this capacity at all in Atlantic climates.

RESULTS AND DISCUSSION

Demand for soil functions

In absence of a Soil Framework Directive, there is no single overarching EU policy that comprehensively defines the demand for each of the soil functions. Instead, this demand is framed by a large number of EU policies. The most important of these are listed in Table 1.

Table 1

Demands for the delivery of soil functions, EU policy drivers and the scale of application

EU Policy Driver	Function(s) of relevance[1]			Scale at which demand is framed
Common Agricultural Policy (CAP)	P			EU
Areas of Natural Constraint (ANC)	P			EU / National
Greening Measures	H	C		Ubiquitous
Nitrates Directive	W	N		Ubiquitous / Regional
Water Framework Directive	W	H		River Basin District
Habitat & Birds Directive	H			Multiple scales
Agri-Environmental Schemes	H	C	W	Farm / regional
EU 2030 Climate and Energy Framework	C			EU + National targets
Sewage Sludge Directive	N			Regional

[1]P = primary productivity, W = water purification, C = carbon sequestration, H = habitat provision, N = nutrient cycling

Table 1 illustrates that the demand for soil functions is framed at a wide range of scales, depending on the targets specified within each of the policies of relevance. For example, the targets of the Nitrates Directive and of the greening measures are ubiquitous: they apply to every farm within the EU. The Water Framework Directive differs from the Nitrates Directive in that it uses both chemical and ecological criteria to set targets for water quality. These ecological criteria are largely a function of the integrated management (agricultural and otherwise) of river basin districts, rather than of individual farms. At the other extreme, the EU 2030 Climate and Energy Framework has thus far only specified targets for greenhouse gas reductions at EU level. Over time, this is expected to translate into national targets, but there are many difficulties associated with further downscaling these targets to regional or indeed farm level [11]. In relation to nutrient cycling, both the Sewage Sludge Directive and the Nitrates Directive require that a sustainable ‘home’ be found for nutrients from human and livestock derived waste, respectively. One of the main constraints and considerations in this respect is the logistics and costs of transport, which bounds the demand to find this sustainable home to a regional level. Finally, the Habitat and Birds Directives frame the demand for the soil function ‘habitat for biodiversity’ at multiple scales: at national scale, they require the designation of NATURA 2000 sites, while at farm level they simultaneously impose mandatory actions to safeguard the protection of endangered species and habitats.

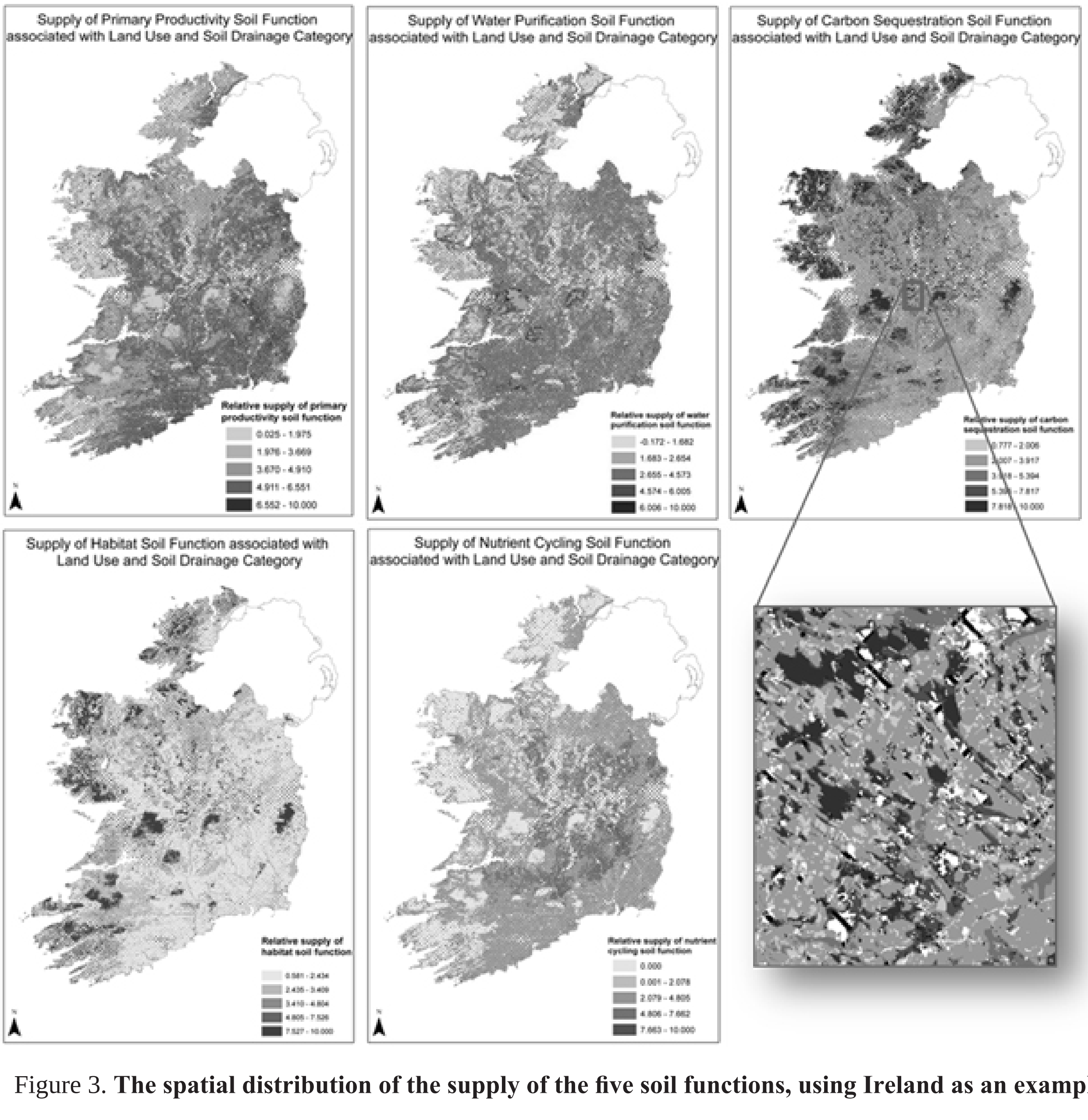

Figure 3. **The spatial distribution of the supply of the five soil functions, using Ireland as an example.**

Supply of soil functions

Figure 3 shows the spatial distribution of the supply of the five soil functions, using Ireland as an example: it shows a high degree of granularity in the supply of each of the soil functions. Whilst some regional patterns emerge, particularly for the provision of primary production, habitat and nutrient cycling, the supply of soil functions is primarily defined by local soil and land use characteristics (inset).

The implications of the spatial scale of application

The issue of scale has implications for the incentivisation and management of individual soil functions. For example, the targets of the Nitrates Directive cannot be offset between regions and must be met on all farms. But the regional focus of the Water Framework Directive allow for a degree of offsetting between land areas at a catchment level. This means, on the one hand, that the impact of individual farms may be ‘diluted’ over a catchment. Conversely, this impact may be compounded by non-agricultural sources of nutrients, e.g. waste water treatment plants. At the other extreme, the demand for carbon sequestration only has national targets, which allows for a degree of offsetting between regions and land uses, as the impact of sequestration on the atmosphere is not locationally bound. This means that it may not be efficacious to translate national carbon sequestration targets into a requirement for every farmer to offset his/her emissions through land management. Instead, it may be more prudent to focus the delivery of this soil function on soils less suitable for the primary productivity function, e.g. by incentivising farm forestry on these latter soils.

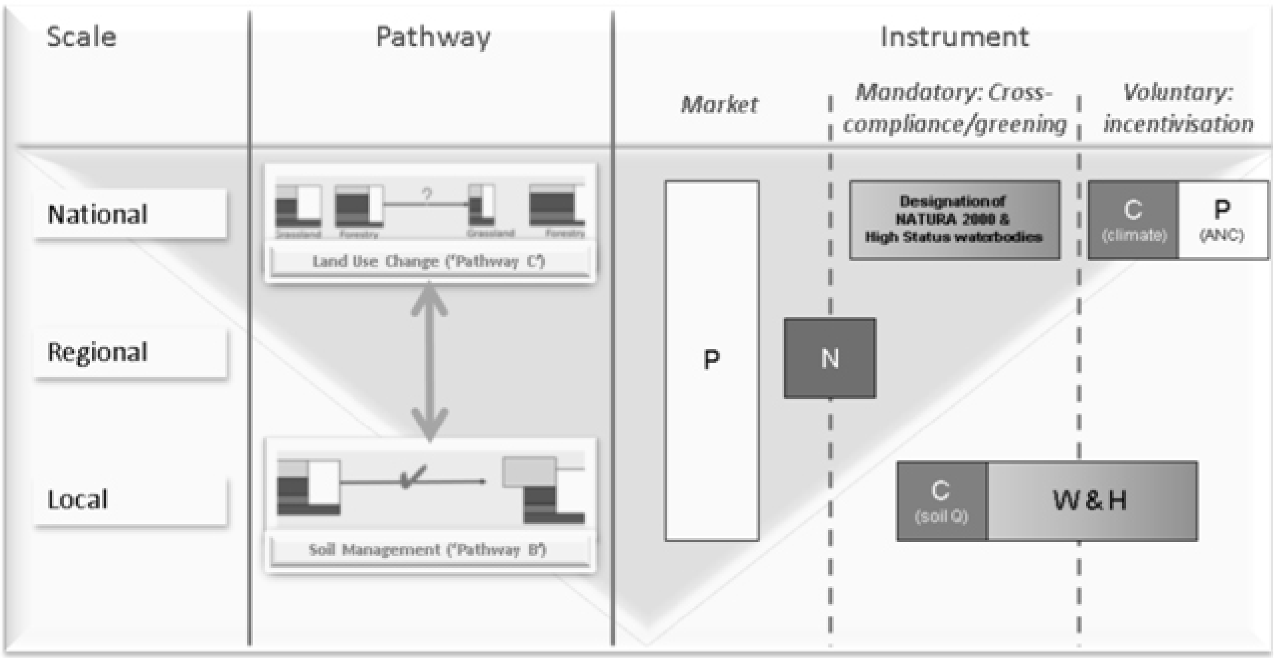

Figure 4. **Framework for policy instruments that may be used to optimise the supply of soil functions to meet demand at a range of spatial scales.** Legend as per Table 1.

Incentivisation

It is important to emphasise that the concept of Functional Land Management does not lead to the requirement for top-down ‘zoning’ of land for individual functions: the granularity of the supply of soil functions emerging from Figure 3 demonstrates that this may be unachievable in any case. Instead, individual soil functions may be incentivised by a range of instruments that have a long history within the framework of the EU Common Agricultural Policy (CAP). These include mandatory incentives such as the cross-compliance and greening requirements of CAP Pillar 1, as well as voluntary incentives such as agri-environmental schemes and the new Areas of Natural Constraints (ANC) of CAP Pillar 2. In Figure 4, we have endeavoured to categorise these instruments into market driven incentives, mandatory policies and voluntary schemes, and to identify the corresponding spatial scale of application.

Policies at national scale focus on the management of land use. Examples include the mandatory requirement to designate NATURA 2000 sites (Habitats Directive) and High Status Waterbodies (Water Framework Directive). In principle, these two requirements allow for synergy and a seamless approach. For primary productivity, the main instrument to regulate demand is the market, specifically following the abolition of EU milk quota in spring 2015. However, the Pillar 2 payments for Areas of Natural Constraint are an example of a voluntary scheme to compensate farmers for reduced capacity of soils to deliver primary productivity. There is an opportunity to dovetail this scheme with incentives for carbon sequestration aimed at offsetting of greenhouse gases through e.g. farm afforestation, in order to ensure that 'each soil provides the function that it is good at'. At local level, a continuum of incentives are focussed on the augmentation of selective soil functions, ranging from the mandatory requirement to maintain soil carbon contents in excess of 2% in order to maintain soil quality, to voluntary agri-environmental schemes aimed at enhancing local soil management practices to ensure delivery of the water purification and habitat functions.

European scale

In this study, we focussed on Ireland as a case study for which we had data readily available. Added value may be derived from this study by using it as a template for application at European scale, since A) most policies that frame the demand for land use or soil functions are indeed derived at EU scale and B) the potential for offsetting of the supply of soil functions between countries, which raises the question whether each country should (be allowed to) focus on the functions that its soils are good at. Whilst this may be challenging in the context of the EUs principle of subsidiarity between member states, this is the subject of the new Horizon 2020 project of LANDMARK (LAND Management, Assessment, Research, Knowledge base); for details see www.LANDMARK2020.eu or follow @LANDMARK2020.

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HIGHER AGRICULTURAL EDUCATION AROUND THE BALTIC SEA: PROBLEMS AND SOLUTIONS

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Abstract. *As agricultural sector is of fundamental importance for every country and even is one of guarantees of its sovereignty also higher agricultural education is similarly relevant. This paper analyses and compares some important questions (problems) of higher education (the first cycle or bachelor level) in agriculture. Paper is mainly based on the experience of five Universities located around the Baltic Sea: Latvia University of Agriculture (LLU), Swedish University of Agricultural Sciences (SLU), Aleksandras Stulginskis University (Lithuania) (ASU), Estonian University of Life Sciences (EMU) and University of Warmia and Mazury in Olsztyn (UWM) (Poland). Totally 2661 students studied in analysed programs in 2014. History of higher agricultural education in region is 150-200 years long and rich in traditions. Further described questions were analysed and compared: interpretation of the term "higher education in agriculture", prestige of agricultural education in every specific country and motivation for young people around the Baltic Sea to study agriculture; their dreams for future job possibilities and real places of work as well as employers' expectations from graduates of agricultural programs; the number of students in Agricultural programs and possible reasons for drop-out are searched. Regulations for enrolment and matriculation as well as funding of studies, and possibilities of internationalization of education in agriculture are compared. Organization of study process and teaching aids as well as students' characterization is given. Length of studies at the bachelor's level and some peculiarities in curricula including diverse length of practice and different demands for bachelor's theses are compared. Quality control of study programs is examined. Problems with teaching staff for agricultural students of next generations are reflected. At the end of paper a little insight in future development plans of agricultural programs are outlined.*

Key words: *bachelor's degree, previous knowledge, bachelor's thesis, praxis, motivation.*

INTRODUCTION

Agriculture is of fundamental importance for every country despite the small percentage from the gross domestic product produced by the sector. Statistical data (2011) shows that depending on the country in Baltic-Scandinavian region crop and animal production, hunting and related service activities constitute 3.6% in Poland, 3.2% in Lithuania, 2.2% in Estonia, 2.0% in Latvia, 1.0% in Finland and 0.4% in Sweden from the gross value added (at the basic prices). Nevertheless, agriculture is important for every country's sovereignty and it is best of all said by Jean Jacques Rousseau: "If you own all the wealth of the world, but you have nothing to eat – you are dependent on others. Trade creates wealth, but agriculture offers freedom". Together with the development of sector gross added value is produced by decreasing number of people, but most of them live in rural areas and take care not only for production, but also for the environment and community. Employment in agriculture from the total employment in six above mentioned countries ranges from 3.3% in Estonia to 12.4% in Poland.

By the year 2050, the Earth will need to feed 2 billion people more than it is at present [1] and this is the greatest challenge for the sector. The main resource for production – agricultural land – when calculated in ha per capita is better provided in the region around the Baltic Sea if compared with many other parts in Europe and the whole world. Utilised agricultural area (2011) per capita in European Union is among the biggest in Lithuania, Latvia and Estonia (0.92, 0.88, 0.71 ha per capita, respectively), but also in Sweden

(0.33 ha per capita) it is 1.6 times bigger than that in Germany. At the same time climate scientists forecast that Baltic-Scandinavian region can have some benefit from the global climate change, which can be mostly limiting factor for agriculture in many other regions of the world [2]. There is a great potential to develop diversiform agricultural sector also in future.

Agriculture nowadays can develop successfully only if well educated professionals and staff are available. European Commission emphasises the role of science, innovations and education for successful development of agriculture in immediate and more distant future [1],[3].

Several authors have analysed development of agricultural education in a specific country (e.g., [4]-[9]), but during last years analysis and comparison of daily problems of higher agricultural education in several countries, including Baltic Countries, is not done. In addition, despite the fact that European Universities follow Bologna process regarding the levels of education (Bachelor, Master and Doctoral), national peculiarities still exist.

The aim of this paper is to compare and analyse some important questions (problems) of higher education (the first cycle or bachelor level) in agriculture in countries around the Baltic Sea: Latvia, Lithuania, Estonia, Sweden, and Poland.

MATERIALS AND METHODS

This paper is mainly based on the experience of five Universities located around the Baltic Sea: Latvia University of Agriculture (LLU), Swedish University of Agricultural Sciences (SLU), Aleksandras Stulginskis University (Lithuania) (ASU), Estonian University of Life Sciences (EMU) and University of Warmia and Mazury in Olsztyn (UWM) (Poland). Several universities are providing higher agricultural education in Poland, due to this literature sources were used as well (e.g. [9]). Information was summarized by authors of this paper using official documents of specific university usually provided in national language, and interviewing staff and students. Mainly bachelor level education is described. Analysis and synthesis, monographic method and interviews of experts were the main methods used.

RESULTS AND DISCUSSION

Brief history of higher agricultural education development

History of higher education in Agriculture in Baltic – Scandinavian region dates back to 19th century. The very first (even in the scale of the whole Europe) was Department of Agriculture in old Vilnius University (Lithuania) established at the Faculty of Physics-Mathematics in 1819. In Poland, higher Agricultural education was established in the early 19th century: Institute of Agronomy in Warsaw-Marymont was founded in 1816, but it started to work in 1820. In Estonia, the first was Tartu Veterinary School founded in 1848 (education in veterinary medicine is not analysed in this paper), but Department of Agriculture was established at Tartu University only in 1919. Also in Sweden higher education in agricultural science has been offered for over 160 years at the Ultuna (Uppsala), but Alnarps Institute was founded in 1862, which was closely followed by the Department of Agriculture at Riga Polytechnic School (Latvia) in 1863. Agricultural education in Olsztyn has been offered since 1950-ties.

During 150-200 years of higher agricultural education development, many changes were passed including institutional and program changes.

How differently do we interpret the term "Higher education in Agriculture"?

Initially, it was designed to analyse undergraduate level or Bachelor's degree, or first cycle education related to plant production (agronomy) and animal production (zootechnics or animal husbandry) in this paper. However as it turns out, the content hidden under the term „Agriculture" differs depending on the country as well as institutions and/or faculties involved in education. In Latvia, it is agronomy (field agronomy as well as horticulture), animal husbandry and entrepreneurship in agriculture. All above mentioned is taught in Faculty of Agriculture of LLU in Jelgava, which is the only place in the country to obtain this type of education. In Lithuania, it is possible to study programs *Agronomy*, *Agricultural Technologies and Management*, *Landscape Architecture,* and *Quality and Safety of Food Raw Materials* at the Faculty of Agronomy of ASU (Kaunas), but Faculty of Animal Husbandry (not analysed in this paper) is established at the other institution: Lithuanian Veterinary Academy. In Sweden, all programs connected with agriculture are studied at the SLU, but there are involved three faculties in two study places: Faculty of Landscape Architecture, Horticulture and Crop Production Science (based in Alnarp), Faculty of Natural Resources and Agricultural Sciences (based in Uppsala), Faculty of Veterinary Medicine and Animal Science (based in Uppsala). Six programs are related to agriculture and they include such fields as agronomy, animal science, economics and management, rural development and food science. In Estonia, no more faculties exist. Instead of this Institutes are established at EMU and two of them are responsible for education in agriculture: Institute of Agricultural and Environmental Sciences (responsible for bachelor's degree in crop production and horticulture) and Institute of Veterinary Medicine and Animal Sciences (in charge of the bachelor's degree in animal husbandry, not analysed in this paper). In Poland, currently 6 agricultural universities are functioning, including University of Warmia and Mazury in Olsztyn, Faculty of Environmental Management and Agriculture. Agricultural education can also be found on the agricultural departments at other Universities, which are in total 19 in Poland.

The classification in academic and professional programs at undergraduate level is more characteristic to Latvia, where three different program types in higher education are established: academic programs that offer bachelor's degree, programs of the 2nd level higher professional education offering professional qualification and Professional bachelor's programs that offer professional bachelor's degree and professional qualification. Agricultural education went through all these types and now the Professional Bachelor's program Agriculture (240 ECTS) has been developed (since 2011) that combines the best from both previously realized programs (academic bachelor's and 2nd level higher professional education programs) [6]. Students after graduation acquire professional bachelor's degree in agriculture and one chosen professional qualification: an agronomist specializing in either field crops or horticulture, or a zootechnician (i.e. animal husbandry expert) in breeding, or a manager of an agricultural enterprise. Such program offers academic knowledge as well as practical training and internship in farms or other agricultural enterprises. Development of such the so called "umbrella type program" (under umbrella of professional bachelor's degree four professional qualifications can be chosen) was connected with the demand of Agricultural sector which needs more practically trained specialists [6],[7]. In Lithuania (240 ECTS) and Estonia (180 ECTS), education is academic, but in Sweden it depends on the program: bachelor's program *Agricultural and Rural Management* (180 ECTS) is more professional during the two first years and more academic during the third year. Also, this program offers bachelor's degree as well as a professional qualification. Specialization is chosen during the 3rd year (animal production, crop production, business administration or technology). All other agricultural programmes (270 ECTS, 4.5 years) in Sweden have a strong academic foundation and in reality are closer to master's level than to bachelor's level although it is not a complete master's degree according to Swedish regulations. In Poland (UWM; 210 ECTS), the first cycle education is academic, but graduates do not obtain the bachelor's degree; for them the title "engineer" is conferred.

Prestige of agricultural education around the Baltic Sea

Everyone who studies or teaches agriculture is proud of that. But prestige of education in agriculture is not very high in all cases. Despite the very high international rating of SLU, Swedish colleagues recognize that "education in agriculture is not so well known for either society or young people. It is probably valued more by society than by young people in general." In Latvia, the situation is interesting due to the fact that even secondary school teachers do not recommend highly successful learners to study agriculture saying that they are capable of doing more than simply studying agriculture. It gives evidence about lack of understanding from society, what modern agriculture means and that substantial knowledge is needed for successful business, and that this business can be very cost-effective in reality. It is a problem for Faculty of Agriculture of LLU to educate society on this issue. Lithuanians believe that agricultural education is becoming more and more prestigious judging by the increased number of students at Faculty of Agronomy of ASU. But about Estonia the answer is direct: "unfortunately education in agriculture is not considered prestigious by society and young people". In Poland, the reason of relatively low popularity of agricultural studies in the future may contribute relatively little payment for this type of university graduates. The report of Sedlak & Sedlak (2012) (http://sedlak.pl/en/Salary_reports.html) on the salaries of graduates of various specializations in Poland shows that agricultural graduates are the second least-paid, while the first ones are those who have graduated from pedagogical establishments.

What is the motivation for young people around the Baltic Sea to study agriculture and what do they want to do after studies?

In Sweden, the *Agricultural and Rural Management* students are very interested in agriculture and want to learn more. They all are already connected with agriculture, because that is a requirement for entering the program. In other degree programs (270 ECTS) motivation of students is different: some of them come from a farm, or are very interested in animals, others are interested in environmental or poverty issues, and see an education in agronomy as a chance to learn more about these issues and a way of gaining the tools to make a difference for poverty, global warming, feeding the world's population. Food science students have a special interest in food, product development, health. Plant/soil students are interested in agriculture and environmental science. About 50% of Lithuanian students are connected with farming and their main motivation is to get good job after obtaining bachelor degree or to return to their own farm. Similar is the primary motivation of students in Latvia from which 60-70% depending on the year are already related to agricultural enterprise – a farm, Ltd, farmers' cooperative. As the main reasons for coming to Faculty of Agriculture they mention the perspectives of acquired education for good job possibilities and the circumstance that they are from a farm and have to continue to manage it after their parents' retirement. In Estonia, about half of the students are personally linked to agricultural production or at least rural life. Some students are interested in food production systems in general. Unfortunately some students have chosen this field randomly (which means that their motivation is low and they often leave the program during the first year). About 20-30% of students come from families who own the agricultural enterprise and they plan to implement their knowledge in their family farm. According to F. Rudnicki [9], in Poland, agricultural studies mainly take the children whose parents are farmers, the successors of farms.

It seems that the broadest look on agriculture and its importance (poverty problems, global warming, feeding the world's population) have Swedish students, but for those in Latvia experience in his/her parents farm sometimes is not a contributory factor, but vice versa – obstructive for progress because students want to learn only things particularly needed for their own farm in a current situation.

When the students are asked to tell about their plans for future, Latvian students mostly want to be managers of agricultural enterprises or specialists in such enterprises, a small part of them expresses a wish to work as advisors or in governmental institutions, very few – in scientific institutions, and nobody or sometimes only one – in institutions connected with agricultural education. Several (approximately 10%) students also want to continue studies at the next (master) level. Answers from Lithuanian students are not expanded, but it is known that during the 4th study year 80-90% from them already have jobs in agricultural sector. In Estonia, most students aim to go to work at the agricultural sector or state institutions, some want to continue at their family farm and about 50% of graduates want to continue studies in master's level. As for Sweden, there are two level multi-shaped programs analysed. Also, the wishes for future jobs are different. The *Agricultural and Rural Management* students (BS level) want to work in their own agriculture company or in the agriculture field as a farm manager, farm foreman, teacher, advisory officers in several areas as animal production, buildings, crop production and economics, sellers of insurance, feed or equipment, product engineering, technician, consultant, bank clerk, animal welfare inspector, etc. Only a few want to continue education in Master's course. When speaking about students in other programs (270 ECTS), not many students want to be farmers after finishing their education at *Agriculture program – Economics and Management*, rather they want to be advisors to farmers, either at a bank, as accountants, or for the state, at a department or a county administration. Some want to work as controllers at firms within the agricultural sector, such as a grain or dairy cooperative. Almost all agronomy-economy students combine a MSc-degree (120 ECTS) with their agronomy-degree (270 ECTS). Most students from the program *Agriculture program – Food Science* are interested in product development in food industry, quality control, food industry jobs, some want to work for governmental agencies, R&D, some want to continue with Master's course – this number is increasing. Students from the program *Agriculture program – Soil and Plant Sciences* are interested in advisory activities, government activities, R&D, activities in developing countries, some continue with Master's course – also here this number is increasing.

What do employers expect from graduates of agricultural programs?

Higher education in European Union is a result-oriented. Graduates from the agricultural programs have to demonstrate a set of knowledge and comprehension, have to achieve definite skills and competences. All this is formulated for every program, but as so many programs with relatively various contents are included in this survey from five countries, we do not repeat here everything, but concentrate on similarities at bachelor's level. Everybody without a reference to the country, university or study program has to obtain specific knowledge in agriculture mainly based on biology, technology, economics, and available resources. They have to know laws and regulations in agriculture, to combine theoretical knowledge with praxis, and demonstrate the ability to make assessments within the area of agricultural operations with regard to cross-disciplinary aspects of production, marketing, the environment, function, ethics and society. They have to be able to work independently and to use scientific achievements into agricultural production, to read critically and discuss scientific or other literature in agriculture, to take responsibility for production process and results. They have to have the ability independently identify their need for additional knowledge. Some programs (e.g. in Latvia and Lithuania) identify their ability to continue studies in the next level (master program). At the end it can be summarized that our graduates are aimed to be creative, open-minded, socially active, responsible and capable of free communication personality, high quality specialist who can work at agricultural enterprises, state institutions and local authorities, advisory services, agro-environmental and science institutions and as entrepreneurs capable of doing competitive business.

Number of students in Agricultural programs

It is hard to compare the number of students in agricultural programs among analysed countries because in some only one university is involved (Latvia, Sweden, Estonia), but in others – two or more Universities or other Institutions (Lithuania, Poland, see above). Although the number of students in agricultural programs did not form a big proportion from all the students at university and college level in the whole country (e.g. in Latvia this proportion currently is 0.4%, but in Poland – 1.7%), this number is stable year by year in Latvia and Estonia, a little bit fluctuating in Sweden or even persistently increasing in Lithuania during the last six years (2009-2014; from 66 applicants in 2009 up to 262 applicants in 2014 at the Faculty of Agronomy). In Poland, a clear reduction in the number of students in agriculture is observed during last 30 years. Currently, it is observed that agricultural studies mainly take children of Polish farmers, the farms' successors. However, in recent 20 years the number of people working in agriculture decreased approximately twofold and the number of farms is decreasing [9].

An interesting indicator is also a proportion of graduates from the number of students admitted in the first year. In Latvia, this proportion in analysed situation (Table 1) was 58% in 2014. In Sweden – depended from programs and in bachelor's program it was 65%, but on average in other programs which require studies for 4.5 years (270 ECTS) it was 47%, in Estonia and Lithuania it is about 40%, but in UWM (Poland) about 86%.

Table 1

Number of students in Agricultural programs

Country and number of programs	Number of students in 2014		
	1st year students	Totally in programs of Agriculture	Graduates
Latvia (one program)	111	374	64
Lithuania (four programs)	262	820	102
Estonia (two programs)	80	182	32
Sweden (bachelor's program one)	51	194	33
Sweden 270 ECTS programs (five)	157	840	74
Poland, *University of Warmia and Mazury in Olsztyn* (one program)	65	251	56

When comparison is made between the number of the 1st year students and graduates (Table 1), some idea about dropout during studies arise. Dropout always is a significant indicator for a study program, but given signals can be various: students made a wrong choice or they are simply passers-by without any specific interests, they are not prepared well enough at the secondary school and it is hard for them to follow one or some subjects, they are not ready for self-dependent work or self-dependent life in a student hostel, etc. The survey of students and teachers in different countries showed that there are some problematic fundamental study subjects which can cause difficulties at university: chemistry is mentioned by Latvia, Estonia and Sweden, biology by Latvia and Estonia (in Estonia, an additional stress is placed especially on genetics), mathematics is singled out by Sweden and Latvia and physics – by Latvia. In Lithuania, at secondary school students at their 16 have to make a choice what subjects will be important for the studies at university, and they make some mistakes choosing subjects which do not help to study in programs related to natural sciences. These mistakes are corrected at the University, taking extra classes in problematic cases for small extra payment.

This seems to be a problem for both parties (secondary schools and universities) to co-operate in order to equalize the education process and make it possible for secondary school leavers to continue successfully education at the university.

Regulations for enrolment and matriculation

Students in all countries are admitted to the programs according to the results achieved at the secondary school. Entrance examinations are not demanded by university. In Latvia, Estonia and Lithuania the so called state-centralized-exams are organized at the end of the secondary school, and applicants participate in the competition with these results. Sometimes, the final grade at secondary school can be utilized. In Latvia, the results of state-centralized-exams of Latvian and foreign languages are required as well as the result of state-centralized exam or final grade at secondary school in biology. Additional points in competition can give the result of centralized exam or final grade in chemistry. In Estonia, results of state-centralized-exams in Estonian language and mathematics are required. In Sweden, admission to the agriculture programmes requires general and specific entry requirements based on courses from the Swedish upper-secondary school. For bachelor's program (180 ECTS) he/she has to be a holder of Swedish upper-secondary school certificate and at least a minimum grade of "Pas" in the upper-secondary school project etc. In addition, a professional experience in farming is required for the bachelor's *Programme in Agricultural and Rural Management*. It is the only case from analysed in this paper when professional experience is required for entering the agricultural program. When entering other programs (270 ECTS), specific subject are designated: Swedish or Swedish as a second language, English and Mathematics.

Financing of studies around the Baltic Sea

In all the countries the state budget is the main payer for agricultural studies, but some differences exist from country to country. In Sweden, only the state budget pays for education in agriculture even for foreign students if they are citizens of the EU or European Economic Area (EEA). In Latvia, state budget pays totally for 213 students every month. Students have to compete for those places according to their weighted average grade. During the last years 80 places are reserved for admission of the 1st year students and they compete for them with their grade at secondary school and have to meet other entering requirements. Those who failed to obtain budget financed place have to pay for studies themselves. Rotation of students according to their success in studies from budget financed place to self financing and the other way round is organized after each semester. All the part time students have to pay for studies themselves. A similar situation is in Lithuania where students can study in budget financed or self financed places. In Estonia, full time higher education is free of charge and currently there are no part time students. In Poland, the situation is different: full time students study free of charge (i.e. by state budget funding), but part-time students are co-financed by state budget and students themselves.

Length of studies at the bachelor's level and some peculiarities in curricula

In Latvia and Lithuania despite the difference of programs (academic in Lithuania and professional bachelor's program in Latvia) the study length is 4 years achieving at least 240 ECTS. The development of bachelors program *Agricultural and Rural Management* at the SLU was interesting due to the fact that initially it was a two-year-course, for some time even one-year-course, but since 2010 it is a three-year long program. Students can finish the program also after two years earning a professional qualification with the Higher Education Diploma in Agricultural and Rural Management (vocational degree) presently. Other analyzed programs are 4.5 years long and students after earning 270 ECTS can graduate from them with Degree of Master in Science of Agriculture or study a little longer and obtain Master's Degree. Bachelor's program in Estonia is classical according to Bologna process, i.e. 3 years long (180 ECTS), but one in Poland is 3.5 years long (210 ECTS).

In Latvia, Lithuania, Estonia and Poland all the study subjects are divided into three main groups: 1) General education subjects; 2) Subjects of the major field; 3) Field professional or deeper specialization subjects. Also, free elective subject courses are offered in small amount (e.g. 9 ECTS in Latvia, 12 ECTS in Lithuania and 8 ECTS in Estonia). In Sweden more options are given to students to combine the list of study subjects.

Practical experience even from applicants just graduated from university is often required by employers. Amount of field practice included into curricula depends on the program and country. In Sweden, practice is required as matriculation requirement for BS program, but in other programs (270 ECTS) it is included in the group of elective study courses at the amount of 15 ECTS. In Latvia, practical experience is given within the study program during the two different kinds of practice (totally 39 ECTS): 1) field practice under guidance of teaching staff (10.5 ECTS) and internship in farms or other agricultural enterprises (28.5 ECTS). In Latvia, it is considered that praxis, especially internship in farms is among the most important components of curricula of the program *Agriculture* [7]. Despite the academic trend of agricultural programs in Lithuania, Estonia and UWM (Poland), field practice is also included into programs at the amount of 19, 15 and 6 ECTS, respectively. Nowadays students have to have good English so that they can read about the latest scientific achievements and for better comprehension of modern Agriculture, as well as for successful exchange studies. Unfortunately, knowledge of English is insufficient for approximately 50% of students in the program *Agriculture* in Latvia. Classes in amount of some ECTS of professional English (or German) are offered in Latvia as well as in Lithuania and Estonia (6, 3 and 4 ECTS, respectively). Polish information tells that "the student must obtain a pass with a modern foreign language at the B2 level of the European Framework of Reference for Languages" and courses of foreign language in the amount of 8 ECTS are included in curricula. Language course is not included in curricula in Sweden. The reason of such differences can be found in the peculiarities of history of included countries – students and even teaching staff from comparatively new European countries (Poland, Latvia, Estonia, and Lithuania) still need to improve their English language skills for successful co-operation in education and science in Europe and world. In Sweden, master level studies are organized in English for both, Swedish and foreign students. At the same time only some courses or modules are offered in English for ERASMUS exchange students in other countries.

To finish the program preparation and defence of different size bachelor's theses are demanded (Table 2). Only Estonian students can make a choice between working out the theses and passing bachelor's examination, but students in Poland have to carry out theses and to pass diploma examination.

Table 2

Brief insight into the demands for bachelor's theses depending on country

Country	Amount in ECTS of bachelor's* theses	Demanded content
Latvia	18	**Literature review and** depending on chosen specialization – field or vegetative, or laboratory experiments; studies in animal breeding or nutrition; analysis of actual farm management
Sweden	15	**Literature review**; in addition, **students can** also do experiments, interviews, questionnaires, case studies, behavioural studies, visual tests, laboratory tests etc.
Poland* (UWM)	15*	Compulsory Literature review; preferable project or experiment based thesis
Lithuania	12	Final thesis can be theoretical or experimental. Independent simple research work is advisable
Estonia	10	The field-work based theses are preferred, but due to lack of experiments there are many literature based reviews as well

*– in Poland, Engineer theses

Organization of study process and teaching aids

Study process is mainly organized traditionally. Students have lectures, practical and laboratory works, case studies, projects, tasks, exercises, computerised exercises, field studies; they have to prepare term works, to write and present reports orally. There are not recognized evident differences among universities. All those works might be aimed at enhancing critical thinking, problem-solving and decision making skills in students, but success of all mentioned possibly more depends on teacher's personality and talent, but not on university itself. Also, modern teaching aids such as multimedia, interactive-boards, modern equipment in laboratories for experiments, different computer programs for data processing and simulation of processes are used.

Possibility of internationalization of education in agriculture

Nowadays in the era of postmodernism, internationalization processes in the whole world are very strong It concerns also the higher education. More and more foreign students from Asia and other parts of the world want to study in Europe. On the other hand, e.g. Latvia faces a problem of decreasing number of total population including young people who want to study at Universities. A similar situation is described in Poland – gone are the days when for some programs in agriculture, e.g. gardening, there were 10 applicants for one place. Currently, some Polish universities do not run studies in this direction because of lack of applicants.

Is it possible to attract foreign students in Agricultural programs at the analysed universities at bachelor's level? Mostly the bachelor's level studies are offered in the national language. In English only courses for ERASMUS exchange students are offered in Latvia, Lithuania, Estonia and Poland. None of mentioned countries has regular foreign students. In Latvia in addition, it is believed that agriculture is region-specific (climate, crops, soils etc.) and it is hard to teach the same curricula for next agronomists in Latvia and e.g. India. In Sweden, master level studies are offered in English and it means that foreigners can study without a language barrier. Also, a solution is found in master level with the curricula offering the program *Agroecology* for students from all over the world with globally significant content at SLU, Alnarp. LLU, EMU, ASU and UWM are designing studies for foreign students in future.

What are students in six countries around the Baltic Sea?

Young people are quite similar all over the world: some are excellent, but some – lazy, some are socially active, but some love their own farm and feel best of all in-between crop fields or animals. A very nice characterization of Swedish students is given by Johan Toren: "The students often report projects, tasks and exercise orally to all students and they do it very well. They are very active in discussions at lectures and seminars. … Our students are very verbal, active, and enjoy presenting orally and using power point with high quality!" Active, inquisitive students are the dream of every teacher. Latvian students are not very active questioners, but when they need to present power point presentations, they do it very well. They love Latvia very much and only some dream about international studies or career.

We all can agree that activity of students during classes is directly connected with the competition for the study place: in years when more applicants with better grade compete for study places, coming students are more active and motivated to study hard. But, for instance, in Poland "the number of study places offered by Polish universities and colleges far exceeds the number of young people leaving secondary education schools and aspiring to study. This is difficult, because the school's or university's the raison d'être is to educate someone. Therefore, the basic problem of universities is to tap candidates including the ongoing problem of growing demographic low college-age youth" [9]. Also, in Latvia the number of secondary school-leavers is decreasing with every year and it means that competition for study place is not very high.

Graduates from bachelor's programs at work

In Latvia, it is required to follow the actual job situation of graduates for three years. 90-95% of them have job in the agricultural sector or continue studies at the next level. Demand for agronomists and animal husbandry experts (zootehnicians) from state authorities, advisory service, agricultural companies is continuous and Faculty of Agriculture cannot meet this demand due to the reason that most graduates return to their family farms or companies. In Lithuania, graduates from Faculty of Agronomy are successfully employed by agriculture and food industry, agriculture and rural development, infrastructure of business and public administration spheres. Estonia does not have such statistics yet (but in 2 years the state will start evaluating the efficiency of their teaching by evaluating the graduates and then the budget of university will depend on the number of graduates actually working in agriculture). But as mentioned before, 50% of them continue education at the next level. According to the investigation of F. Rudnicki [9], in Poland the principal place of work for graduates is a farm and institutions and companies with respect to agriculture and rural areas. According to research results conducted by University of Warmia and Mazury in Olsztyn, in 2014, on the fate of graduates showed that out of 64 people who have finished the Faculty of Agriculture and Environment in 1999: 15% are employees at universities, 10% are working as teachers in secondary agriculture schools and vocational agriculture schools, 15% work in banks, 15% work in their own companies, 15% work in the agricultural environment, 10% are employed in state institutions related to agriculture, 5% are employed in public administration, 5% are employed in police and military, 5% are managers of agricultural enterprises, for 5%, their current professional paths could not be determined (some of them went abroad).

Swedish graduates have different job possibilities depending on the agriculture related program they graduate. Those with vocational degree (120 ECTS) or BS degree (180 ECTS) in *Agricultural and Rural Management* mainly work in their own agricultural company or in the agriculture field as a hired specialist. Those who graduate from 270 ECTS programs have different occupation. Holders of "Degree in agricultural science – economics and management" can look forward to a broad labour market. They are competitive outside the agrarian sector as well, and often find employment with banks, accountancy firms, real estate agents, auditing companies etc. also with no agrarian link. In Latvia, such specialists are also taught at LLU, but in Faculty of Economics and Social Sciences. Holders of "Degree in agricultural science – animal science" find employment at various companies, organisations and public authorities with a link to animal food production, or animal-related in other ways. Examples are the following: an animal husbandry advisor, animal welfare officer, geneticist, feed developer, teachers of animal science, construction advisors etc. Holders of "Degree in agricultural science – rural development" can find employment in international (e.g. the Council of Ministers) as well as Swedish national (e.g. the Department for Rural Affairs) and regional contexts (such as the Rural Economy and Agricultural Societies). Holders of "Degree in agricultural science – food" can be found at different levels within the food industry, not only in primary production but also further down the processing chain. Several authorities (such as the Swedish National Food Agency) and organisations working with food quality and food inspection also employ food graduates. In Latvia, such specialists are also prepared at LLU, but in Faculty of Food Technology. Holders of "Degree in agricultural science – soil and plant science" are employed within the traditional agrarian sector. Examples are advisory and monitoring tasks with companies and authorities involved in agricultural issues. The demand for graduates specialising in soil and plant science is considerable, and at the moment SLU cannot meet the demand.

Quality control of study programs

All the study programs have to pass quality assurance in which experts (mainly foreign ones) and official national authority is involved. If experts' conclusions and national authority decision is positive, the approval for the program is given for 6–7–8 years depending on the country. At present, all surveyed programs are approved for the longest possible term. Quality control systems are also changing persistently with the aim to improve them.

Who will teach agricultural students of next generations?

Higher education at university level has to be science based and high quality staff is needed for that. The question about the possibility to find new teaching staff in cases when previous educators would like to retire is important. This problem is frequently connected with prestige of sector and very prosaically – also with reasonable funding of education. It is sometimes hard to find teachers with appropriate competence in a specific field. In Sweden, it is easy to find new teachers for general basic science courses, but a problem is to find them for the specific agronomy courses. The most obvious example is technology, where there is a risk that the ambition to include more or at least strengthen the technology content in the study programs is complicated because of lack of teachers with appropriate competence. In Latvia, the most reason why young people do not like to choose a career of teacher or researcher is uncompetitive salaries if compared with those in the Agricultural sector. In the situation when mostly all European countries try to strengthen education and research for better development of national economy funding for higher education in Latvia is only 83-85% (depending on year) from the minimal necessary. But there are enthusiasts who like teaching and research, and confidence exists that students will be taught also in future in Latvia. In Lithuania, in agriculture studies problems with teaching staff do not exist. It is reasoned with quite big number of PhD students defending their theses (more than 10 a year) and many scientists at agricultural research institutions who also can work for the University and teach agricultural subjects. EMU similarly to LLU have big problems to attract young people as teachers. In Latvia and Poland ageing of teaching staff is observed, but reasons for that are diverse. In Latvia, it is lack of young people who want to be teachers, but in Poland according to regulations, professors can work for the state university up to the age of seventy and younger applicants for professor's place cannot get it.

Plans for future development

All the programs have undergone developmental changes in the past, but they are never finished because nowadays life is rapidly changing and agricultural programs have to meet demands of Agriculture Sector and society, supervisory body and accreditation experts, students and teaching staff. Every university is designing how to improve. SLU is planning to make some changes in programs developing them more corresponding to Bologna system: 3 (bachelor level) + 2 (master level) years. The content of study courses is designed to be surveyed and improved in LLU, but ASU is starting to develop a completely new program *General Agriculture* with the length of 3.5 years (instead of four years). EMU wishes to improve the practical aspects of studies and collaboration with farmers. ASU and LLU are dreaming of a joint program with foreign universities. EMU, ASU, LLU and UWM is discussing stronger internationalizing, firstly at least promoting the number of exchange students in different programs (e.g. ERASMUS etc.). All surveyed universities aim to increase the quality of teaching in terms of study materials and methods, teaching aids etc. Also, infrastructure is in continuous perfective maintenance.

CONCLUSIONS

Despite similar aims and achievable study results, analysis and comparison of bachelor's level higher agricultural education at five different universities (LLU, ASU, EMU, SLU and WMU) in the countries located around the Baltic Sea showed a great diversity in study programs which all belong to the family "Agriculture". This paper and our co-operation during preparation of it is a good beginning for further co-operation in order to exchange experience for improvement of our study programs.

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TRENDS IN HORTICULTURE

RESULTS OF FRUIT BREEDING IN BALTIC AND NORDIC STATES

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Abstract. *The specific climate of Nordic and Baltic countries allows profitable and sustainable growing of various fruit and berry crops including rare and novel ones, but demands climate adapted cultivars. Fruit breeding in the region is targeted mostly at the local fruit market and has reached notable results in apple, pear, plum, cherry, blackcurrant and other crops. Modern pre-breeding research and breeding methods have been used with good results, first of all marker assisted selection (MAS). At the same time, the high competition from more southern regions has resulted in decrease or zero growth of fruit production in some countries and subsequent closing or temporarily stopping of breeding programs. The situation looks more promising with berry crops, especially these adapted exclusively to Northern climate, like Vaccinium and Rubus species. Novel crops include, first of all, Japanese quince (Chaenomeles japonica) and seabuckthorn (Hippophaë rhamnoides). Significant differences exist between Scandinavia with a long and uninterrupted history of fruit growing and the Baltic countries which started to develop modern fruit production only since 1990ties. Changes in consumer attitudes create increased demand for locally grown and organic fruits, as well as for more variety in cultivars, and hopefully may lead to increase in funding for breeding in future.*

Key words: *climate adaptation, pome fruits, stone fruits, small fruits, new fruit crops.*

INTRODUCTION

Nordic and Baltic countries form a specific area in European fruit growing. The northern border of growing most of fruit crops runs through the region, and the region may further be divided into several zones – southern, favourable for most fruits (Denmark, Lithuania, south of Scandinavia); central, marginal for such fruits as pear or sweet cherry (Latvia, Estonia, Central Scandinavia lowlands, Southern Finland); northern, favourable mostly for berry crops, including ones which would not grow more south, like Arctic bramble *Rubus arcticus*. While the southern part of the region can, with some limitations, use cultivars from large fruit growing countries like Poland or Germany, the rest must rely mostly on their own breeding programs. This review tries to give a brief summary of the present situation and recent results in fruit breeding.

CLIMATE AND SITUATION IN FRUIT GROWING

If compared with other European fruit growing areas, the climate in Nordic and Baltic countries can be characterized by:

– Cool, rather short growth season with active t° sum marginal for some crops e.g. pear;
– Relatively high rainfall and low evaporation (hydrothermic coefficient – HTC);
– Long days in summer (high count of sunshine hours);
– Rather frequent extreme winter temperatures (below – 25...30°C) in most of the region;
– High differences in climate zones even inside a single country;
– In the southern part of region – unstable snow cover and frequent winter thaws;
– In the northern part – high and stable snow cover.

This climate allows profitable and sustainable growing of various fruit and berry crops including rare and novel ones, but demands climate adapted cultivars and careful choice of growing zones. As all fruit crops are perennial, the negative effect of stress on plant health tends to accumulate. Winter hardiness, including resistance both to extreme temperatures and to temperature fluctuations, is the main limiting factor. Length of the growth season also is limiting and does not allow to use very late ripening cultivars. Day length is mostly important in strawberry growing as their flower bud formation directly depends on it.

Resistance to fungal diseases in conditions of relatively high moisture has allways been important in the region. Winter injury, too, increases susceptibility to infection. Climate change has negative effect on plant health, and some plant diseases and pests have moved more north, like fire blight *(Erwinia amylovora)* and sharka virus (PPV). On the other side, the local climate allows a reduced number of pesticide sprayings.

The whole region gives just a minor part of total European fruit production, e.g. 140 000 t apple as compared to 10 mill.t in EU 28 and 2.5 mill. t in Poland alone (FAOSTAT). The high competition from more southern regions has resulted in decrease or zero growth of commercial production in some countries. The situation looks more promising with berry crops, especially these adapted exclusively to Northern climate, like *Vaccinium* and *Rubus* species, and new crops e.g. Japanese quince and seabuckthorn. Areas of these crops are increasing. It may be supposed that the future focus of breeding, too, may change to these species.
At the same time, local fruits and berries are produced in amounts that do not meet consumer demand. There is also a tendecy to return to a higher diversity in cultivars, and increased consumer interest in fruits grown close to home and organic production. Improved storage technologies may mean that genetically late maturing of a cultivar is no more that important.

BREEDING PROGRAMS AND RESULTS OF BREEDING

Fruit breeding programs in most of the region almost entirely depend on state funding, although there are some succesful private breeders. Unsufficient funding may be explained both by the necessary longterm investment, as well as the relatively low scale of local fruit production in general, in which home gardens still play a significant role, and by competition from other regions. Growing local and export markets for some soft fruits and new crops, and new storage technologies can change the situation. Changes in consumer attitudes mean that breeding of disease resistant and climate adapted tree fruits also should be continued.
National fruit breeding programs at present exist in all countries, except Denmark, although the scale differs. Balsgard, Swedish Agricultural University (SLU) is closing or freezing a significant part of breeding programs at present. In Finland fruit breeding is in the competency of MTT (Agrifood Research Finland), while in Norway – Graminor AS. In Baltic countries the programs are carried out by Polli Horticultural Research Centre (Polli HRC) at Estonian University of Life Sciences, Lithuanian Institute of Horticulture (LIH) and Latvia State Institute of Fruit-Growing (LSIFG), although in Latvia breeding is done also by the private Pure Horticulture Research Centre (Pure HRC) and some other private breeders (consolidation is planned in 2015). Common breeding projects have been active among Nordic and Baltic countries.
The breeding and pre-breeding in Nordic and Baltic States has included marker assisted selection (MAS) mostly for disease resistance in apple [1],[6],[15], sweet cherry S-alleles [14],[22], fruit flesh quality [16],[17]. Marker assisted screening of genetic resources (pre-breeding) has been carried out in most countries.
Complex traits for which almost no markers exist include climate adaptation e.g. winterhardiness. In Nordic and Baltic countries this is a breeding priority, achieved by traditional longterm breeding and using the potential of well-adapted local cultivars. Molecular mechanisms and potential markers for strawberry cold hardiness are studied at Graminor in the framework of a joint project [12].

Apple *(Malus)*

Apple is the most widely grown fruit crop, including local cultivars from controlled breeding like ‘Aroma’ (Sweden) in Scandinavia and ‘Auksis’(Lithuania) in Baltic states, both registered in 1970ties. There certainly is a field for improvement, joining fruit quality and storage potential with complex resistance (using MAS) and climate adaptation. Other targets are improved firmness, texture and biochemic content; easily manageable tree. Most breeding programmes in the region have included two valuable scab resistance donors, formerly obtained in Sweden – BM41497 (gene Vf or Rvi6) and SR0523 (gene Vm or Rvi5) [1],[6].
At SLU-Balsgard the breding program (till 2013) used significant genetic research and MAS [15]-[17], including allergenes. The latest developments are scab resistant cultivars ‘Frida’® (club variety), ’Fredrik’ and variety candidates ‘Augusta’, ‘Fanny’, ‘Folke’, ‘Lovisa’, ‘Sofia’, polygenic resistant ‘Agnes’, ‘Trulsa’.
In Norway apple breeding program started in 1980ties, targeted for early ripening and low susceptibility to scab. The newest cultivars are ‘Eir’, ‘Idunn’, ‘Nanna’ and ‘Siv’ [20].
Finland is the northernmost country growing apples. The apple breeding program (till 2003) has given a number of cultivars, which are early ripening, have high winter-hardiness, but medium scab tolerance. The latest cultivars are ‘Tobias’ (suitable for storage), ‘Jättimelba’, ‘Petteri’, ‘Talvikki’, ‘Talvikaneli’. Breeding of rootstocks resulted in obtaining a series from MTT1 (very dwarfing) to MTT5 (medium vigour).
In Estonia many new cultivars have beed created at Polli HRC. The combine good disease tolerance with good flavour, mostly sweet. The most promising seem to be ‘Liivika’ and ‘Krista’. Some have storage potential –

'Aule', 'Katre', 'Kersti'. Scab resistant hybrids are in trial – 'Kelin', 'Kikeriki', 'Virve' etc. Of new crabapple cultivars the best is 'Kuku' [8]. Some rootstock breeding also has been done.
In Latvia the controlled breeding started at „Iedzeni" in 1940ties was continued by LSIFG and Pure HRC, taking over large hybrid material in 1990ties; 25 apple cultivars have been released since 2002 [9]. The most interesting are – early ripening 'Roberts' (Vf) and 'Agra'; midseason – 'Dace' (Vf), 'Gita' (Vf), 'Eksotika', 'Joko'; late – 'Pure Ametist', 'Laila'; very late - 'Monta' (Vf); columnar – 'Inese' (Vf), 'Baiba', 'Zane'. Scab resistant (Vf) 'Edite'and 'Ligita' have been registered also in Belgium, 'Joko' – in South Africa by „Color" Ltd., breeding partner of Pure HRC. Some breeding is done for red-leaved, columnar and cider apples.
In Lithuania breeding of disease resistant apples recently has has resulted in cultivars 'Aldas', 'Skaistis', 'Rudenis' (all Vf). Breeding continues with donors of scab resistance, using MAS [1].

Pear *(Pyrus)*

Winter hardiness is the main limiting factor for growing pear in the region, along with the ability to develop good flavour after cool summers, and better storage. The lack of suitable cultivars means that pear areas in the region are small, the biggest – in Denmark and Norway.
Norway has the best breeding results for fruit quality, although not for winter-hardiness. The breeding program in cooperation with Sweden (1983-2000) still brings forward new cultivars and variety candidates. These include 'Ingrid' (early), 'Kristina' (scab tolerant), 'Celina' (blushed), the last in most promising in commercial trials [5]. Promising hybrid is NP10130, in Latvia – NP2870 and NP61.
Pear breeding at SLU-Balsgard is not continued at present, but BP8965 and 10529 have showed good results in Latvia and hopefully will be registered as cultivars.
In Lithuania a number cultivars have been registered from the breeding material obtained earlier, including 2 since 2010 – 'Liepona' and Gaisra'. Of previously registered cultivars 'Lukna' (midseason) is considered promising for commercial plantations [13].
In Latvia targeted crosses were done since 1973 by R.Dumbravs. 'Suvenirs' is among the most widely planted pears in Latvia, but lacks storage potential [3]. Newer cultivars with better storage potential are 'Balva' and 'Selija'. At present breeding is continued at Pure HRC in a joint project with „Color" Ltd.
In Estonia pear breeding is done on a smaller scale, the main target being winter-hardiness. Newer cultivars are 'Kadi' (dark red), 'Polli Punane' (redflesh). Unluckily, none of them is large-fruited [8].

Japanese quince *(Chaenomeles japonica)*

Japanese quince, rich in aroma and vitamin C, was first grown as a fruit crop in 1970ties in Latvia. In 1990ties controlled breeding started. In cooperation between LSIFG, SLU-Balsgard and LIH, the first in the world cultivars for fruit production were released – 'Darius', 'Rondo' and 'Rasa' [9], with improved fruit quality and production characteristics.

Rowan, mountan ash *(Sorbus)*

This species has quite good market potential in Latvia, and there are about 4-5 ha of commercial plantations, mostly Russian cultivars. At Pure HRC in 1993 inter-generic hybridization was started with pear (*Pyrus domestica*) and hawthorn (*Crataegus submollis)*, and 2 hybrids are pending for registration. Breeding continues in cooperation with partners in South Africa, Germany, Czechia, Canada.

Domestic plum *(Prunus domestica)*

Domestic plums have long been grown in the region, but the occurring climate change has put new stress on tree health and regular production. The plum pox virus (sharka) occurence is the region has become dangerous. Climate adaptation, disease resistance, self fertility and fruit size are the main breeding goals; breeding is done mostly for dessert fruits with different time of ripening. At present there are a few state funded breeding programs. Breding program in Norway was interrupted in 1997 because of sharka virus destroying most of the material, and renewed in 2001; it yet has no registered cultivars. In Lithuania breeding at present is done in cooperation with Graminor AS, Norway.
In Baltic countries a plum breeding program continues at Polli HRC. Many winterhardy cultivars have been released and are grown commercially. The newest selections are 'Villu', 'Reeta', 'Kaidi' [8].
In Latvia 4 cultivars with large dessert fruits have been obtained in cooperation with Swedish partners – early ripening 'Ance' (yellow), midseason 'Adelyn' (yellow with blush) and 'Sonora' (purple, self-fertile), late 'Lotte' (blue, sweet, lower winter-hardiness). All have good market quality and storage potential [9].

Sweet cherry *(Prunus avium)*

Breeding of sweet cherries in the region is targeted, first of all, at improving winter hardiness and fruit quality (size, firmness, resistance to cracking), obtaining self-fertile cultivars and compact tree. At present breeding programs are active in Baltic countries.

In Estonia, Polli, the sweet cherry breeding program continues since 1945 and has resulted in numerous winterhardy cultivars [8]. Cultivars 'Anu', 'Arthur', 'Elle', 'Karmel', 'Kaspar', 'Madissoni Roosa', 'Meelika', 'Mupi', 'Norri' and 'Polli Murel' are recommended for commercial growing [11]. Most have relatively small and soft fruits; a few are above 5 g – 'Anu', 'Irma', 'Mupi', 'Polli Murel'.

In Latvia the program was started in at "Iedzeni" and continued in 1990ties at LSIFG. The first registered cultivars of LSIFG were 'Aija', 'Indra' and 'Janis' selected from open-pollinated seedlings of the local population. New large-fruited cultivars are 'Paula' (yellow) and 'Artis' (dark red). Recently self-fertility and compact tree donors have been included in crosses [9]. Cultivar 'Ugis' was named at Pure HRC in 2013.

In Lithuania the breeding program started in 1965, and 9 cultivars were released till 1996. Of these 'Vytenu Geltonoji', 'Jurgita', 'Auste' and 'Vasare' are recommended for commercial growing in Lithuania, 'Vytenu Juodoji' is planted in Latvia. The newest releases are 'Gema', 'Irema', 'Luke' in 2012.

Sour cherry (*Prunus cerasus)*

Sour cherry breeding is done on a very small scale. The main reason is massive drop of growing areas, because widespread diseases – leaf spot (*Blumeriella jaapii*) and brown rot (*Monilinia laxa*) are dramatically reducing productivity and tree survival. In Lithuania 'Vytenu Žvaigžde' and 'Note' were released before 2001. M. Jensen at Aarhus University, Denmark at present is working on developing methods of resistance evaluation in sour cherry (http://dca.au.dk), including hybrid evaluation.

Apricot *(Prunus armeniaca)*

Apricot is a marginal crop in the region, but breeding with significant results has been performed in Latvia. Two breeders started this process in 1950ties – P.Upītis in Dobele and V.Vārna at Botanical Gardens, University of Latvia, using material from Caucasus, Central Asia mountain areas and the northern frontier of apricot cultivation in Europe. The problems to be solved are short dormancy, susceptibility to spring frosts and temperature fluctuations in winter, susceptibility to fungal diseases and self-sterility. In 1999 first apricot cultivars were registered in Latvia (LSIFG) – 'Daiga', 'Lasma' and 'Velta' [10]. In 2004 'Jausma' and 'Rasa' from the Botanical Gardens were registered. Promising hybrids have been selected also at Pure HRC.

Peach *(Prunus persica)*

Breeding of peach was done by V.Vārna at Botanical Gardens, University of Latvia. Only the 4th generation was suitable for growing in open field [10]. In 2004 two cultivars were registered – 'Maira' (most hardy) and 'Viktors'. At present peach breeding is not continued, but 2 elite seedlings have been selected at Pure HRC. Of these `Venita` shows better hardiness than 'Maira'.

Strawberry *(Fragaria x ananassa)*

Strawberry is among the most widely grown crops in the region, but the breeding programs are not impressive. The main reason is the high adaptation abilities of most strawberry cultivars; the best are grown worldwide. Yet winter-hardiness is essential, especially in regions with unstable snow cover, and is one of the main breding targets in the region. Another problem is adaptation to the long day. Breeding for disease resistance is also done, especially mildew.

Mildew resistant cultivars with good fruit quality 'Suvetar','Valotar', 'Kaunotar' and ''Luvetar' have been released by MTT, Finland, and hybrids with everbearing cultivars have been selected [4]. In Norway mildew resistant cultivars 'Gudleif', 'Iris'and 'Blink' were released in 2007 [23]. A few winterhardy, productive cultivars have been relatively recently released in Baltic countries – 'Suitene' in Latvia by Pure HRC, 'Dange' and 'Saulene' in Lithuania.

Raspberry *(Rubus idaeus)*

The aims of raspbery breeding are regular high productivity and improved fruit quality, combining of cold hardiness with tolerance to fluctuating temperatures common in the Baltic sea region, with good disease resistance. The biggest raspberry breeding programs now exist in Norway, Latvia and Estonia**.** Breeding of primocane cultivars was done previously in Sweden.

The Latvian program at LSIFG has included also large fruit gene L1 donors from Russia. Cultivars ‘Ina’, ‘Lina’, ‘Liene’, ‘Viktorija’ have been released; the first has the highest market potential. The main problem at present is resistance to bushy dwarf virus; marker assited breeding has started [9].
In Estonia, cultivars ‘Aita’and ‘Alvi’ were released in 2008, hardy, productive and with good quality [8].
In Norway the longterm breeding program is targeted at quality, productivity and disease resistance; some promising hybrids have been selected.

Arctic bramble *(Rubus arcticus)*
The southern border of *R.arcticus* in wild reaches Estonia. It is a species adapted exceptionally to cool or subarctic climate and thus the speciality of Northern Europe. Some commercial plantations have been established. Breeding was started in 1970ties, cultivars include ‘Anna’, ‘Beata’ (Sweden), `Astra`, `Aura`, `Pima`, ‘Mespi’, ‘Susanna’ (Finland) [24].

Blackcurrant *(Ribes nigrum)*
Blackcurrant is one of economically most important berry crops in Northern Europe, a valuable source of vitamin C and anthocyanins, rich in aromatic components. There are two directions of breeding – berries for dessert and for processing (and mechanical harvest). The main problems are suceptibility to diseases, especially mildew (*Sphaerotheca mors-uvae*) and gall mite (*Cecidophyopsis sp*.), which is a carrier of blackcurrant reversion virus (BVR). Susceptibility to spring frosts because of early bud break also is included in breeding programs. Interspecies hybridization and marker assisted breeding have been used in Latvia and Lithuania. In 2007-2011 *Ribesco* project helped to analyse blackcurrant genetic resources in Europe, providing valuable data for breeding programs.
Cultivar – ‘Karina’ was released in 2012 from a common breeding project of Latvia, Sweden and Lithuania.
In Latvia cultivar ’Mara Eglite’ was registered in 2004 by National Botanical Gardens (program closed). It is large-fruited, late ripening and highly productive, even when infected by gall mite to which it is susceptible.
In Lithuania, blackcurrant breeding has resulted in a number of cultivars suitable both for processing and dessert – ‘Almiai’ (highly productive), Joniniai’ (early), ‘Gagatai’ and ‘Kriviai’ (high quality), ‘Vakariai’ (resistant to gall mite) [21]. Recently released are ‘Dailiai’, ‘Gojai’, ‘Salviai’, ‘Senjorai’, ‘Svajai’.
In Estonia the newest cultivars are ‘Ats’ (spring frost resistant), ‘Almo’ (long racemes), ‘Elo’ (early), ‘Karri’ (both dessert and processing). They all are disease resitant and have large fruits [8].
In Finland, 2 blackcurrant cultivars ‘Marski’and ‘Mikael’ have been released recently, as well as 2 green-fruited cultivars ‘Venny’ and ‘Vilma’ with high vitamin C content [7].

Red and white currant *(Ribes rubrum)*
Breeding of red and white currants is done in Finland. Intense red ‘Punahilkka’ [7] and white ‘Lepaan Valkea’ and ‘Piikiön Helmi’ are recent releases.

Gooseberry *(Ribes grossularia)*
There are no active breeding programs. In Latvia, a few gooseberries were selected from a closed breeding program; thornless cultivar ‘Rita’ (dark red, late) was released in 2011.

Blueberry *(Vaccinium spp.)*
Blueberry areas in the region expand, but in its northern part climate adaptation of American highbush cultivars is not sufficient. The Finnish cultivars ‘Arto’, ‘Aino’ and ‘Alvar’ were obtained in hybridization with *V.uliginosum* and/or *V.angustifolum* [7]; newer crosses are ‘Jorma’, ‘Saani’, ‘Siro’, ‘Sine’. In Sweden ‘Putte’, ‘Emil’, in Lithuania ‘Danute’, ‘Freda’ are *V. corymbosum* × *V. angustifolium*. At National Botanical Gardens, Latvia, 2 *V.ashei* cultivars have been registered – ‘Lielogu’, ‘Salaspils Izturīgā’, as well as *V.corymbosum* cultivar ‘Agrīnais Kovills’ [19].

Cranberry *(Vaccinium macrocarpon, V.oxycoccos)*
Cranberry is a typically northern crop, yet the commercial growing zone of American cranberry (*V.macrocarpon*) lies more south than the area of the local bog cranberry (*V.oxycoccos*). In areas suitable for American cranberrry, cultivars from the USA are most widespread, but some breeding also has taken place. The main tasks of breeding are earlier ripening, uniform size and intensive colour, productivity, disease resistance. In Latvia *V.macrocarpon* cultivars obtained at NBG have been just registered – ‘Kalnciema Agrā’, ‘Kalnciema Tumšā’, ‘Kalnciema Ražīgā’, ‘Septembra’.

All cultivars of bog cranberry have been selected from wild populations. In Estonia at Nigula Nature Reserve H. and J.Vilbaste have selected and in 1996 registered 6 cultivars: 'Kuresoo', 'Maima', 'Nigula', 'Soontagana', 'Tartu', 'Virussaare' [11]. In Lithuania, Kaunas Botanical Gardens, 5 clones have been selected – 'Amalva', 'Žuvinta', 'Vaiva', 'Vita' and 'Reda'.

Lingonberry *(Vaccinium vitis-idaea)*

Lingonberry is mostly harvested in wild, but commercial plantations also exist. At SLU Balsgard cultivars 'Sanna' and 'Susi' were developed some time ago. In Latvia breeding was done at NBG, resulting in cultivars `Salaspils Ražīgā`, `Jūlija` and `Rubīna Lāse`, released after 2010.

Cranberry-lingonberry hybrids

In Latvia, NBG intespecific hybrids between *Vaccinium macrocarpon* x *Vaccinium vitis-idaea* have been obtained by A.Ripa – 'Dižbrūklene', 'Salaspils Agrā' and 'Tīna'. These are first such cultivars worldwide, with fruits resembling cranberry, but plant more compact and upright [19].

Seabuckthorn *(Hippophaë rhamnoides)*

Seabuckthorn is one of the fastest expanding fruit crops in and Northern Europe, although recently a newly arrived pest *Rhagoletis batava* has put it at risk. The main breeding tasks are: fruit quality (size, firmness, stalk length, biochemic content), suitability to mechanical harvesting, reduced thorniness, productivity, disease resistance, climate adaptation (from *H.rhamnoides ssp.rhamnoides*). Study of molecular markers was started in Sweden [2]. In Latvia breeding is done privately by A.Brūvelis and K.Blūms, who have obtained cultivars 'Marija', 'Tatjana' and 'Lord' (pollinator) [9].The first registered cultivars in Finland are 'Terhi' and 'Tytti', obtained by X-ray radiation of seeds [7].

Grape *(Vitis)*

Growing of grapes in Nordic and Baltic states is gradually becoming commercial, in which breeding of winterhardy and early ripening cultivars has played a crucial role.

In Latvia the first succesful cultivars were obtained by P.Sukatnieks, using crosses between *Vitis vinifera* and winterhardy *V. labrusca*, *V.amurensis*. His cultivars 'Guna', 'Sukribe', 'Supaga', 'Zilga' have been widely planted. Yet they increasingly suffer from downy mildew (*Plasmopara viticola*) and lose popularity.

At present the most successful breeder in Latvia is G.Vēsmiņš (LSIFG) [9]. Starting with *V.vinifera*, he later included in crosses also a very early *V.amurensis* mutant and a *V.vinifera* x *V.riparia* elite hybrid. His breeding aims are: short growth season (90-110 days) and early shoot maturing; berry quality equal to dessert *V.vinifera* cultivars; cold tolerance (– 23º...– 25ºC); resistance to mildew and other diseases. His cultivars are 'Dovga', 'Liepājas Dzintars', 'Liepājas Agrā', 'Cīravas Agrā', 'Silva'.

Good results in grape breeding have been achieved in Lithuania till 1990ties, but not later.

Kolomikta kiwi (*Actinidia kolomikta*)

A.kolomikta is ar hardy kiwi species with small and soft fruits, unsuitable for long storage, but with very high vitamin C content. Breeding at Kaunas Botanical gardens, Lithuania has resulted in 4 registered cultivars 'Laiba', 'Lanke', 'Lande' and 'Paukštes Šakarva' [18].

CONCLUSIONS

Fruit breeding in Nordic and Baltic countries is targeted mostly at the local fruit growers and has reached notable results in apple, pear, plum, sweet cherry and even grape breeding. Good results have been achieved also in breeding of small fruit – mostly blackcurrant, *Vaccinium* and raspberry. Novel crops include, first of all, Japanese quince and seabuckthorn, as well as *Rubus arcticus* (Arctic bramble). At the same time, fruit breeding in the region experiences difficulties due to reduced public funding, and there is a tendency to close or freeze breeding programs. Still, present changes in consumer attitudes may result in increased demand for fruits and berries grown close at home, which in turn would create need for breeding of suitable cultivars.

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ENTOMOVECTORING IN BERRY AND FRUIT CULTIVATION IN FINLAND: THE CHANGE IN CAP AND ITS IMPLICATIONS FOR THE FUTURE

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Abstract. *The new support scheme for Finnish fruit and berry growers is explained by Reskola, V-P. (2015), Ympäristökorvaus käynnistymässä. Puutarha & Kauppa Nr. 3/2015, p. 14. In Finland, new CAP measures dealing with environmental subsidies to agriculture, propose to change the statutes and to include specifically entomovectoring. Conventional growers, who replace chemical fungicide sprays by entomovectoring of microbial products on their berry and fruit crops for a minimum of 5 years, will receive 500 €/ha/year in environmental support. It is expected that the new subsidy scheme will encourage berry and fruit growers to take up the alternative method. The model which Finnish legislation is providing might help other countries also to adopt a similar scheme. What is at stake in Finland are the consequences of unguided introduction of the new technology. There is no infrastructure to support the introduction and uptake of the entomovectoring technology. In case growers run into problems, no infrastructure is available to provide knowledge and know-how for the introduction of the new technology. If the technology fails on the fields, it is because of the mode of introduction.*

Key words: *antagonist, Apis mellifera, apple, biological control, Bombus, Botrytis cinerea, CAP, Clonostachys rosea, dispenser, entomovectoring, environmental subsidies, fungal diseases, Fusarium avenaceum, Gliocladium catenulatum, integrated control, new CAP measures, organic production, Prestop® Mix, raspberry, strawberry.*

INTRODUCTION

In Finland, new CAP measures dealing with environmental subsidies to agriculture, have changed the statutes to include specifically entomovectoring. Conventional growers, who replace chemical fungicide sprays by entomovectoring of microbial products on their berry and fruit crops for a minimum of 5 years, will receive 500 €/ha/year in environmental support. The new support scheme for Finnish fruit and berry growers is explained by Reskola (2015). It is expected that the new subsidy scheme will encourage berry and fruit growers to take up the alternative method. The model which Finnish legislation is providing might help other countries also to adopt a similar scheme. The following sections are based on an article (Hokkanen et al., 2015) reporting on the results gathered in an Europe-wide EU ERA-NET CORE ORGANIC 2 project BICOPOLL (Biocontrol and Pollination).

WHAT IS THE PROBLEM WE ARE DEALING WITH?

Gray mold *Botrytis cinerea* is one of the most important airborne diseases of fruits and berries, like strawberry, blueberry, and raspberry, and can seriously reduce yield and postharvest quality (Strømeng, 2008). The disease results mainly from latent infection of flower parts, which under favorable conditions develops into rot once fruit begins to ripen. The open flower, white bud, and senescent flower stages are most susceptible to infection, whereas flowers at the green bud stage are relatively resistant. Infections at the white bud stage, however, are much less likely to lead to gray mold than infections at the open flower stage. The incidence of gray mold correlates strongly with environmental variables during the flowering period, particularly long periods of high relative humidity. Gray mold is managed principally by protecting flowers from infection.

Using biocontrol agents to manage *Botrytis* has received much attention in the last decade. The use of pollinating insects for the biological control of plant diseases and pests has its origins in the early 1990s (Peng et al., 1992), when honeybees were first used to disseminate biological control agents to strawberry flowers as a replacement for insecticides. Subsequently the concept was termed 'entomovector technology' by Hokkanen and Menzler-Hokkanen (2007), and a more systematic development of the pollinator-and-vector technology was established. This environmentally friendly control strategy, where control agents against plant pathogens and insect pests, are delivered directly onto crop flowers, while simultaneously fulfilling the pollination requirement, represented an innovative way of crop protection for organic as well as conventional cropping systems. Because the appropriate BCA is colonizing the flowers, natural disease suppression is achieved as a consequence of the frequent pollination visits at each inflorescence (Smagghe et al., 2012). The unique concept of entomovectoring incorporates several ecological components, including pollinators, biocontrol agents, and plant pathogens and/or insect pests (Kevan et al., 2008). However, its success is based on mutual and compatible interactions between the appropriate components of the vector, control agent, formulation, and dispenser, and the safety of the environment and human health, in particular the operator/manager at the farm. One of the reasons which has led to the development of the entomovectoring technology as a biocontrol strategy was the need to reduce the application of environmentally harmful synthetic pesticides. Concerns regarding the impact of conventional chemical pesticides on human health and the environment, and the development of resistance by pests, have led to the search for alternative methods. Also, biological control methods, where BCAs have been used as conventional applications (e.g., biofungicides), often have resulted either in poor control, or in too high application costs, resulting in slow progress towards an ideal system. The entomovectoring technology represents a promising alternative, wherein pollinators achieve a dual role: control agents are directly delivered on the target location (i.e., the flowers), while the pollination needs are fulfilled (Mommaerts & Smagghe, 2011; Jedrzejewska-Szmek & Zych, 2013; Ceuppens et al., 2015). In this way the BCA forms an effective disease and pest management tool during flowering of the crop, and during the development of fruits, since the flowers are the main location of infection by plant pathogens (e.g., *B. cinerea*) and insect pests (e.g., the western flower thrips *Frankliniella occidentalis*). Control of these infections by the entomovector technology can thus increase marketable fruit and berry yields (Mommaerts et al., 2011), and even play a role in controlling post-harvest diseases, such as *Alternaria alternata* (Nallathambi et al., 2009).

WHAT IS OUR CONTROL AGENT?

For a good description of the control agent used for our field trials, consult the following link, patent application: http://www.google.com/patents/US5968504

It is known that fungi of the genus *Gliocladium* have fungicidal activity. *Gliocladium virens* strains, especially the *G. virens* strain G1-3, have been described in patent literature. A problem in the use of this species has been the difficulty to produce a formulation of this fungus, in which the viability of the fungus would keep on a satisfactory level during the storage of the formulation.

The Product “Prestop® Mix” is based on *Gliocladium catenulatum* fungal strains, which were found to be very active against a number of deleterious fungi.

The product Prestop® Mix is based on the active ingredient of fungal strains belonging to the species *Gliocladium catenulatum* and optional carriers. Examples of such formulations are compositions suitable for seed dressing, or to treat the soil.

The soil samples, from where the fungal strains of the invention have been isolated, were collected in the years 1989 to 1991 from different parts of Finland, mainly from the research stations of MTT (Agricultural Research Center), from different soil types, and different crop rotations using barley and wheat as bait plants. The samples were taken from the root layer (from the depth of 0 to 15 cm). Several subsamples were taken from each field, which were pooled to samples of 1 to 2 liters.

The fungal strains isolated from the soil samples were tested with the screening method described in the FI patent application 94 0463. Then five strains were found, which gave very good results. The strains, which were named *Gliocladium catenulatum* J1446, *Gliocladium catenulatum* M67-6, *Gliocladium catenulatum* J2734, *Gliocladium catenulatum* M2423 and *Gliocladium catenulatum* M3081, where characterized at DSM (Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH) in Germany. These strains have been deposited on May 19, 1994 according to the Budapest Treaty to the DSM depository by the accession numbers DSM 9212, DSM 9213, DSM 9214, DSM 9215 and DSM 9216, respectively.

PATHOGENICITY OF THE FUNGAL STRAINS

Efficacy of the J1446 fungal strain in the control of plant diseases was tested in a number of tests on eight plant species in total. None of the tests showed any detrimental effect of J1446 to the development

of the plants, even when in some of the tests especially the seeds of the plants were treated, sometimes with quite high doses. On the basis of this it is evident that J1446 does not impede the development of the plants.The mycelia of the fungal strain J1446 have not been noticed to penetrate into the mycelia of other fungi.
The *G. catenulatum* fungal strains have proven to be promising to be used in the biological control of plant diseases. The strain J1446 effects well against three very common soil-borne causes of damping-off: *Rhizoctonia solani*, *Pythium* and *Fusarium* fungi. Additionally, good results have been obtained with the strain J1446 in the control of seed-borne diseases cause by the fungi *Alternaria* and *Fusarium*. With the fungal strains and their formulations good results have been obtained by using amounts, which are realistic in the cultivation in practice. It is also very promising that when mixed with the growth medium they have in tests kept their ability to control soil-borne diseases for long times.

STRAWBERRY AND RASPBERRY GREY MOLD CONTROL

Peng et al. (1992) and Yu and Sutton (1997) reported good control of grey mold in raspberries and strawberries using *Gliocladium roseum*, reducing *B. cinerea* incidence from 90 to 68%, and from 64 to 48%, respectively. To our knowledge, results reported in Hokkanen et al. (2015) represent the first successful use of entomovectoring by growers over large cropping areas. A review of entomovectoring (Mommaerts & Smagghe, 2011) provided a listing of numerous other studies with a wide variety of target diseases, pests, crops, and antagonistic BCA, but could not identify practical applications in crop protection – other than our case in Finland. In the ERA-NET CORE ORGANIC 2 project BICOPOLL the group provided evidence that the control of *B. cinerea* on strawberry by using entomovectoring is possible across Europe, and that control results are similar to chemical fungicides. Furthermore, our Finnish on-farm research results with raspberry (Hokkanen et al., 2015) confirmed that grey mold can be controlled with entomovectoring in commercial production of that crop as well.

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DETERMINATION OF NITROGEN EFFICIENCY BY HALF-HIGH BLUEBERRY CULTIVAR ‘CHIPPEWA’

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Abstract. *Nitrogen management is quite complicated due to it mobility, transformations, vegetative growth and reproductive development, berry biochemical content etc. The nitrogen management for blueberries was chosen as a main topic for experiment set up in Valmiera district in 2012 where plantation was established 2 years ago. Experimental plots with blueberry cultivar ‘Chippewa’ were arranged on gently slope. Original topsoil’s reaction was pH KCl 6.41, organic matter content 20 g kg*$^{-1}$*. Five experimental plots each of them consisting from 8 bushes was set up. Soil reaction was determined potentiometrically, organic matter in mineral soil according to the Tyurin’s method, in organic materials – by dry combustion, total nitrogen using Kjeldahl method. Samples of leaves from each experimental plot were taken during the vegetation for NPK and Fe, Mn, B nutrition diagnosis. Research showed that different nitrogen fertiliser applications significantly influenced Mn concentration in the leaves; however the impact on yield was not significant.*

Key words: *fertilisation, nitrogen forms, blueberry cultivation, soil properties.*

INTRODUCTION

Mineral nutrition studies for high-bush blueberries in Latvia are at a very early stage. In our country, high-bush blueberries are grown in acidic mineral soils and peat bogs. Blueberries are grown in many regions around the world using differently modified soils, having different texture, pH, organic matter content and other soil properties. Therefore, we are not able to use the exact North American fertiliser technology recommendations for all blueberry plants because soil and climate conditions differ significantly. Therefore it is very important to make intensive regional and also local scientific research on blueberry soil and climate requirements, as well as on fertilisation technology [1].

Until now, in Latvia there are very few publications about the influence of nitrogen fertilisation on blueberry growth and development. Therefore, the aim of the current research was to compare the growing rates of nitrogen fertilisers on productivity of blueberries, as well as chemical composition of berries and plant leaves.

MATERIALS AND METHODS

The site and soil characteristics

The research was carried out in a highbush blueberry plantation (established on a 10% north–south slope in 2010) at the farm Abullaci, Valmiera district in 2012-2014. Predominant soil – Endoabruptic Luvisol (Amphisiltic, Aric, Cutanic) (World Reference Base for soil Resources, 2014), fine sandy loam/very fine sandy loam, developed on moraine [2],[3]. The original topsoil reaction – pH H_2O 6.96 and pH KCl 6.41; organic matter content – 20 g kg^{-1}. Before establishing the plantation, substantial improvement (change) of soil properties was done. In 2010, the bushes were planted in rows, deep cultivated, and mixed with acid (pH KCl 3.0±0.3) sphagnum peat. Each year, the same kind of peat was used as a mulch to cover a 5 cm layer on the soil surface between the bushes. During summer, 0.8 m wide strips along the bushes were kept free from vegetation, but grasses were sown and periodically mown in interrow spaces. The experiment layout consisted from five treatments in four replications. Plots were located in different positions on slope, representing one cultivar of highbush blueberries. Each plot consisted of eight fully developed bushes arranged in one row.

In October – November 2012-2014, soil sampling was done in each plot and at two depths: 0-20 cm, 20-40 cm. The following analytical methods were used: pH – potentiometrically in a 1*M* KCl suspension; organic matter for mineral part of soil – using Tyurin’s method, for organic part of soil – by dry combustion; total nitrogen – by Kjeldahl method; plant available phosphorus and potassium for mineral part of soil – by Egner–

Riehm method; for organic part of soil – total concentration after ashing of sample. Two modifications for organic matter and PK analysis were used because soil was conditioned by peat and some part of rows under bushes dominated by mineral soil, another – by organic soil.

Plant material

Plant leaf samples were collected from each plot two times per season: on early July – from previous-year shoots, and on late July – from the new shoots. Samples of the most recently fully expanded leaves that were free from disease or other damages were collected, and each sample consisted of 10 leaves from each of the eight plants. Total nitrogen was determined using Kjeldahl method; total phosphorus and potassium were analyzed after ashing – colorimetrically and by flame photometry respectively. The levels of iron and manganese were estimated by atomic absorption spectrophotometer (Perkin Elmer AAnalyst 700, acetylene-air flame), boron was analyzed colorimetrically by hinalizarine in sulphuric acid medium.

Berries material

Nitrate content was determinated using GOST method 29270-95 p.5 in the Institute of Food Safety, Animal Health and Environment "BIOR".

RESULTS AND DISCUSSION

Productivity of blueberries

The measurements of blueberry yield in experimental plots were started in 2013. The first commercial yield in the plantings where experiment was established was obtained in 2012. The average yield of cultivar 'Chippewa' grown in Latvia in 2008-2012 was around 7-11 t ha^{-1} annually. Nitrogen fertilisation influenced berry yield and data for 2013 and 2014 is shown in Figure 1.

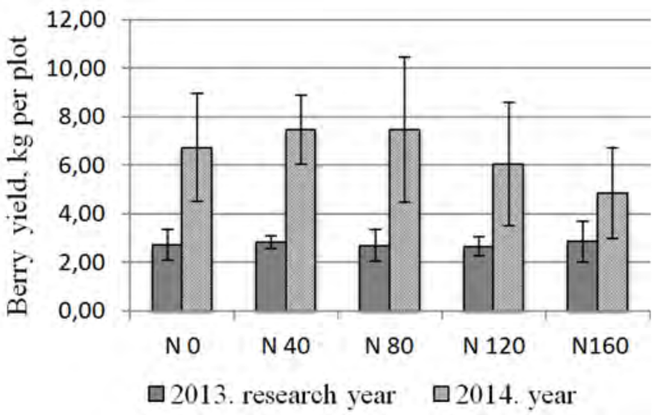

Fig. 1. **Productivity of blueberries in experimental plots in 2013 and 2014.**

There was small yield difference among treatments in 2013, because experiments with fertiliser application were started recently – in 2012. The next year harvest showed more marked variations; although these were no significant in terms of experimental statistics, they indicated only some trend. Here N 80 kg ha^{-1} was more effective for berry production but increased rates of applied nitrogen resulted in yield decrease.

N–NO_3 in blueberries

Some restrictions are set up for nitrogen application for field and horticultural crops in Latvia. For example, for small berries the maximum annual amount of nitrogen application shall not exceed 130 kg ha^{-1} N. If plantation is established in organic soils – even les. Limitation of nitrogen use is set up due for two reasons – food safety and environmental risk reduction. Therefore some control measures was performed to verify abovementioned risks. Nitrate concentration in berries was tested in the treatment where the highest nitrogen rate – 160 kg ha^{-1} N was used. Analytical results affirmed that N–NO_3 concentration not exceed 36 mg kg^{-1} in all replicates that is acceptable for the use of berries for fresh consumption or for processing.

Plant nutrient uptake

Many authors caring out experiments with blueberry fertilisation concluded that this crop does not tolerate high salt concentration in growth media. Over fertilisation can result even in plant's death [4]. This is one of the reasons why fertigation is widely used – systematic supply of nutrients in small concentrations. Using this method variability of nitrogen supply might be performed depending on crop conditions. If the plant grows and develops well, nitrogen application can be reduced or stopped. This will provide the reasonable use of fertiliser resources, to avoid the potential risk of nutrient leaching and also to provide the high yield potential with good quality of berries. As author's shows, special attention should be paid on nitrogen optimization [5],[6].

Some methods should be developed for quick monitoring of plant nutrient supply in crops. Plant nutrient concentration in leaves (or in new shoots) could be the reasonable parameter for plant nutrition diagnosis. Therefore concentration of total nitrogen, phosphorous, potassium as well as iron, manganese and boron were tested in the blueberry leaves in 2014 (Fig 2 and Fig. 3).

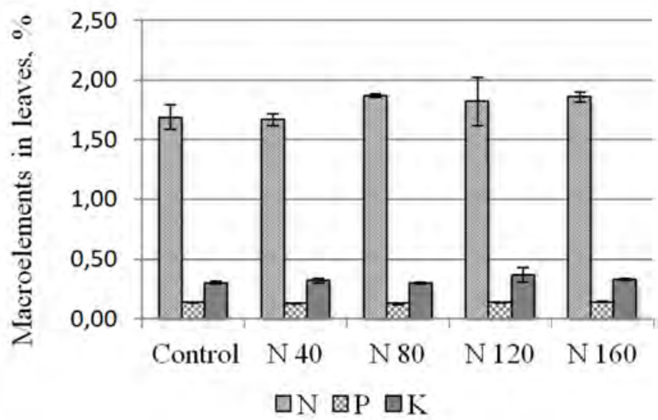

Fig. 2. **NPK concentration in blueberry leaves (dry matter, %).**

There were small differences among the treatments in NPK concentrations in blueberry leaves. Using such data it is not possible to monitor the plant nutrient status in crops. Literature data reports the following reference values for vegetative parts of blueberries: 1.7-2.0% of N, 0.2-0.3% of P, and 0.45-0.7% of K [7],[8]. Compared with that, the nitrogen supply in experimental plants was 1.6-2.05%, phosphorus 0.12-0.14% but potassium 0.29-0.44%.

Generally, in leaves samples the concentration of iron and boron were optimal but manganese was high (Fig. 3).

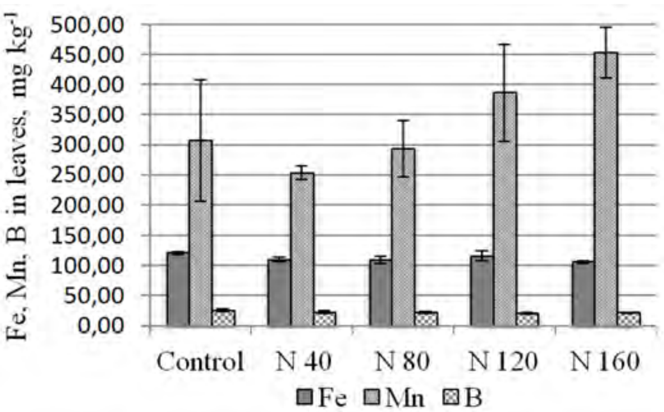

Fig. 3. **Fe, Mn and B concentration in blueberry leaves (dry matter, mg kg^{-1}).**

It is reported that the optimal level of manganese in leaves for blueberry growth is 40-100 mg kg^{-1}. Also data are found that toxic influence of manganese for blueberries occurs when Mn concentration in leaves exceeds 450 mg kg^{-1} [7],[8].

In Latvia the nitrogen deficiency for blueberry plantations is reported in both: cultivating crops in mineral soils and in peatlands. It was confirmed by collecting of leaf examples from commercial plantations and concluded that insufficient N supply may be one of the major factors limiting blueberry yield. In this research done in 2007-2009 was found the plant nutrient scarcity in blueberry plantations. The main problems were the deficiency of N and B, as well as the abundance of Mn. These results indicated that only 39% of all soil parameters in blueberry plantations in Latvian were in the optimal level. It should be noted that the lowest macro- and micronutrient concentrations of blueberry plantation in the soil was comparable to the concentration of nutrients in poor forest soils, thereby pointing to the deficiency of the fertiliser use. Such scarcity could heavily reduce the blueberry yield in Latvia. Although high-bush blueberries like wild blueberries can be considered as typical calcifuges plants as they grow well in nutrient poor soils with low pH, wild blueberries had particularly high K, Fe and Mn intake efficiency and accumulation in leaves. This phenomenon can be seen as a wild plant potential physiological adaptation mechanism in arid soils. However, this mechanism does not exist for cultivated blueberries [1].

Soil properties

Many abiotic factors have a significant impact on blueberry yield including soil properties and soil management [9]. In experimental site soil investigation (morphological observations, sampling) showed that soil cover was not homogenous. In this case soil under bushes originally was (and still is) a typical mineral soil. Soil developed on moraine originally was slightly acid and therefore before planting of blueberries was modified by deep ploughing and peat additions. As the peat mineralisation occurs, every second or third year new peat additions are done. Therefore soil conditions within the plantations are rather heterogeneous – low density, high organic matter and acid soil in strips with bushes and unchanged typical mineral soil between rows. This situation has some priorities, because bushes can utilise plant nutrients found in moraine subsoil which chemically are more rich compared with conditions when blueberries are grown in peatlands.

CONCLUSIONS

Our study is being developed and based on already obtained data we can concluded that productivity of blueberry cultivar ‘Chippewa’ in the first years after using a certain scheme of fertilization (control and low nitrogen norms) is only insignificatly lower. The highest yield was obtained using treatment N 80. Further increase of nitrogen fertilizer did not resulted in the desired results, on the contrary yield reduction was observed (N 120 and N 160).

It is possible that selecting a different cultivar, could cause significant decreases in yield. In our study, chosen cultivar has been established as an interspecific hybrid (*Vaccinium corymbosum* x *V. angustifolim*). It adapts quite well and it is able to produce yield in a certain period of time even without nitrogen fertilizer.

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FRESH AND AIR-DRY BIOMASS OF OREGANO (*ORIGANUM VULGARE* L.) ACCESSIONS

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Abstract. *Oregano (Origanum vulgare L.) is a paramount medicinal plant in Europe. It is necessary to select the most productive accessions for cultivation. The aim of this research was to explore the fresh and air-dry biomass of oregano. The samples for experiment were selected from an ex situ collection of spice- and medicinal plants (latitude: N 56º39`47``; longitude: E 23º45`13``). It is a fundamental collection in Latvia, attached to the Latvia University of Agriculture, Laboratory of Cultivated Plants and Apilogy (Jelgava, Strazdu iela 1). In spring 2012, oregano accessions from this collection was propagated by cloning and grown in the field conditions. At this moment there are 44 accessions of oregano, planted in 4 rows, each accession in 10 repetitions. The accessions are in random order. In summer 2012-2014, stems had been cut, the data were recorded on fresh biomass. The samples had been dried at +26 ºC temperature, the data were recorded on air-dry biomass. The average fresh biomass per plant was 12.72 g in 2012, 127.50 g in 2013 and 195.08 g in 2014. The average air-dry biomass per plant was 5.11 g in 2012, 55.90 g in 2013, 77.96 g in 2014. The results showed that the variability between years and between accessions was significant (p<0.05), but the variability between plants of each accession was not significant (p>0.05).*

Key words: *oregano, fresh biomass, air-dry biomass.*

INTRODUCTION

Oregano (*Origanum vulgare* L.) is classified as medicinal, spice- and ornamental plant [1]. Oregano is used in production of essential oil, in medicine, perfumery, culinary, food and beverage production, aromatherapy, for attracting bees, in sauna switches composition, for bathing [2]. It blooms from June to the end of vegetation, from August it simultaneously produces fruit and seeds [3]. According to the Medicinal and Aromatic Plants Working Group of the European Cooperative Programme for the Plant Genetic Resources oregano is included in the List of "Priority Species" that are the paramount medicinal and aromatic plants in Europe. The general criteria for including oregano in this document were: actual economic use, current conservation status, endemism, restricted range, recent rate of decline, rarity, threat of genetic erosion, eco-geographical distinctiveness, biological characteristics and importance, cultural importance, high social demand, occurrence and frequency in current protected areas, status of protection, ethnical consideration, taxonomic or phyletic uniqueness or isolation, ecosystem role [2].

In Latvia only *Origanum vulgare* L. ssp. *vulgare* were found in nature. Research of Latvian folklore proved that oregano has been utilized in the folk medicine for thousands of years in the Baltic countries [4]. The wild use of oregano is one of the reasons why the wild populations are severely depleted in Latvia. It is necessary to cultivate oregano for keeping a biodiversity of Latvian nature and for meeting the needs of medicinal plant`s production.

Oregano is quite diverse species: it creates various, morphologically and chemically differentiated forms, which are related to the place of their occurrence [3]. Oregano lifespan is about 3-4 years, but many factors can influence the longevity: winter frost, disease, number of cuts [5]. It is important to use local genetic resources in agrocenosis as they are adapted to the Latvian agroecological conditions and possible stress situations in a specific environment [4].

By legislation, local genetic resources of spice- and medicinal plants are defined as local or foreign species that are grown and used in Latvia during long period of time. Cultivated species with their closely related or initial forms adapted to Latvian agroclimatic conditions are also ranked as local genetic resources [4]. These definitions are based on historical information, species` biological features and conservation capacity.

Oregano cultivation needs to get as rich and qualitative yield as possible. That is why local populations have to be explored with the aim to select the most productive accessions [6]. However, in practice Latvian farmers don't pay their attention to the evaluation of optimal qualitative indices of cultivated medicinal and aromatic plants. In competition with foreign growers and producers it is necessary to evaluate the productivity of medicinal plants in agrocenosis.

The researches of genetic resources of spice- and medicinal plants are still innovative in Latvia. It is necessary to pay more attention to evaluation of quality of cultivated accessions, to their productivity, organoleptic and biochemical parameters, winter hardiness, resistance to diseases and pests, biotic stress susceptibility [7].

The aim of this research was to explore fresh and air-dry biomass of oregano accessions.

MATERIALS AND METHODS

Plant Material and Growing Conditions

The samples for experiment were selected from an *ex situ* collection of spice- and medicinal plants (latitude: N 56º39´47´´; longitude: E 23º45´13´´). It is a fundamental collection in Latvia, attached to the Latvia University of Agriculture, Laboratory of Cultivated Plants and Apilogy (Jelgava, Strazdu iela 1). There are 120 accessions of 13 species of spice- and medicinal plants in this collection.

In 2001-2006, thanks to various international projects, the genetic resources of oregano from different places of Latvia were added to this collection. The plants had been collected from nature using the modified method of Professor E. Muižarāja [4]. The main point of this method is the initial visual division of an area into squares and zigzag passing through these squares as well as the random gathering of samples. The oregano collection was planted in 2008 and reconstructed in 2009. In the process of selection of wild accessions, the latitude and longitude were registered; the topographic description of plants was made. All these data are registered in the system of Nordic Gene Bank.

The Draft Descriptor List *Origanum vulgare* L. was published in November 2011. After its methodology characters should be recorded on an average of minimum 10 plants per accession [8]. In spring 2012, 44 accessions was propagated by cloning and grown in the field conditions.

The soil at the trial site was strongly altered by cultivation loam with organic matter content of 2.7 g kg^{-1}, soil reaction was slightly acidic (pH_{KCl} 6.3), P content was 102 g kg^{-1} and K content was 207 g kg^{-1}. Plant care was provided for this collection.

It is proved that fresh and air-dry biomass was the largest in the phase of full blooming [3]. That is why in summer 2012-2014 stems of all accessions had been cut from the ground level to the tip of the plant at the stage of full flowering [8]. The data was recorded on fresh biomass. The samples had been dried at +26 ºC temperature in a special drying cabinet with ventilations. After 3 weeks the data was recorded on air-dry biomass.

Meteorological conditions

According to data of the Latvian Environment, Geology and Meteorology Centre, the average air temperature in 2012 was +6.1 ºC (0.2 degrees above long-term average observations). The quantity of rainfall was 832 mm (125% of normal). The average air temperature in winter was –3.4 ºC (0.5 degrees above long-term average observations). The spring average temperature was +6.1 ºC, the summer average temperature was +16.0 ºC. In vegetation period (from May to the end of September), the average temperature was 14.3 ºC and the total quantity of rainfall was about 373 mm. From 1 May to 7 July (before plant cutting), the average air temperature was 13.7 ºC, the total quantity of rainfall was 114.1 mm.

In 2013, the average air temperature was +7.0 ºC (1.1 degrees above long-term average observations). The quantity of rainfall was below normal (622 mm or 94% of normal). After a close-to-normal calendar winter of 2012-2013, spring of the year 2013 in Latvia was rich in weather contrasts. The spring average temperature was +4.3 ºC, the summer average temperature was +17.5 ºC. In vegetation period (from May to the end of September), the average temperature was 11.4 ºC and the total quantity of rainfall was 330 mm. From 1 May to 15 July (before plant cutting), the average air temperature was 16.6 ºC, the quantity of rainfall was 118.2 mm.

In 2014, the average air temperature was +7.4 ºC (1.5 degrees above long-term average observations). The quantity of rainfall was 725 mm (107% of normal). The spring was the warmest since 1924. The second part of June was significantly colder than normal – the third 10-day period was the coldest ever recorded (3.5 degrees below the 1961-1990 normal). The spring average temperature was +7.5 ºC, the summer average temperature was +16.9 ºC. In vegetation period (from May to the end of September), the average temperature was 12.3 ºC and the total quantity of rainfall was 441.6 mm. From 1 May to 12 July (before plant cutting), the average air temperature was 14.1 ºC, the quantity of rainfall was 90.6 mm.

In scientific literature it was proved that during the vegetation period the influence of air temperature from +20 to +30 ºC and of the quantity of rainfall of about 600 mm on oregano yield is positive [9],[10]. In total, in 2012-2014 the meteorological conditions were not optimal for oregano cultivation and plant biomass creation.

RESULTS AND DISCUSSION

Cultivation is one of the solutions to the problem of over-exploitation in nature. Current guidelines for cultivation should be adapted and made available to Latvia [2]. It is proved that oregano accessions differ by morphology, biochemistry and genetics [7]. The biodiversity of oregano accessions might become a valuable potential for development of new beneficial products and income possibilities for farmers [2].

Oregano as a perennial plant is smaller in the first year of vegetation than in subsequent years [3]. The data of 2012-2014 years are important for evaluation of growth dynamics, plant development and productivity, cultivation planning and strategy, economical calculation. This research is important for successful and profitable oregano growing and production in Latvia.

The results showed that in 2012 the average fresh biomass was 12.72 g per plant (Table 1).

Table 1

Fresh biomass of oregano accessions in 2012, g per plant

Accession number	Interval
2, 28	Less than 6
3-5, 7, 10-12, 14-16, 20, 22, 24, 25, 29-35, 38-40, 42-45	6-12
1, 6, 9, 13, 18, 19, 21, 23, 27, 36	12-20
17, 41, 26, 37	More than 20

Only 4 accessions had the biomass over 20 g per plant. The majority of accessions had the biomass from 6 to 12 g per plant. The accession No. 37 had the highest biomass (27.46 g per plant). The accession No. 28 had the least biomass (4.76 g per plant). The data statistical analysis showed that the variability between accessions was significant ($p<0.05$), between plants of each accession it was non-significant ($p>0.05$).

In 2012, the average air-dry biomass was 5.11 g per plant. The data are presented in Table 2.

Table 2

Air-dry biomass of oregano accessions in 2012, g per plant

Accession number	Interval
7, 13, 14	Less than 3
6, 12, 16, 20, 40	3-4
1-5, 9, 10, 15, 18, 19, 24, 25, 28, 29, 30, 32-36, 38, 39, 42, 43, 45	4-6
21-23, 26, 31, 41, 44,	6-8
11, 17, 27, 37	More than 8

The accessions No. 11, 17, 27, 37 had the largest air-dry biomass (more than 8 g per plant), but the accessions No. 7, 13, 14 had the least air-dry biomass (less than 3 g per plant). The majority of accessions had the results from 4 to 6 g per plant. The accession No. 37 had the biggest result (10.37 g per plant). The accession No. 13 had the least result (2.77 g per plant). The variability between accessions was significant ($p<0.05$), but between plants of each accession it was non-significant ($p>0.05$).

The analysis of both tables showed that only the accession No. 37 had the largest fresh and air-dry biomass.

The results showed that in 2013 the average fresh biomass was 127.50 g per plant (Table 3).

Table 3

Fresh biomass of oregano accessions in 2013, g per plant

Accession number	Interval
4, 5, 25, 11, 21, 23, 24, 32, 38	Less than 50
2, 12, 15, 22, 25, 26, 29, 30, 33, 34, 36, 42	50-100
6, 16, 17, 20, 37, 40	100-150
10, 18, 19, 28, 39, 41, 44	150-200
1, 3, 7, 9, 13, 14, 27, 31, 35, 43, 45	More than 200

The largest fresh biomass (more than 200 g per plant) had 11 accessions, it was the least (less than 50 g per plant) for 9 accessions. The majority of accessions had the results from 50 to 200 g per plant. The accession No. 1 had the highest biomass (269.33 g per plant). The accession No. 23 had the least biomass (8.03 g per plant). The variability between accessions was significant ($p<0.05$), between plants of each accession it was non-significant ($p>0.05$).
In 2013, the average air-dry biomass was 55.15 g per plant. The data are presented in Table 4.

Table 4

Air-dry biomass of oregano accessions in 2013, g per plant

Accession number	Interval
2, 5, 6, 11, 21, 23, 24, 30, 32, 38	Less than 20
15, 17, 19, 20, 22, 25, 26, 28, 29, 33, 34, 36, 41, 42	20-50
9, 12, 13, 14, 16, 18, 27, 35, 37, 39, 40, 43 – 45	500-100
10	100-150
1, 7, 31	More than 150

The accessions No. 1, 7, 31 had the largest air-dry biomass (more than 150 g per plant), but 10 had the least air-dry biomass (less than 20 g per plant). The majority of accessions had the results from 20 to 100 g per plant. The accession No. 7 had the biggest result (194.07 g per plant). The accession No. 23 had the least result (3.51 g per plant). The variability between accessions was significant ($p<0.05$), but between plants of each accession it was non-significant ($p>0.05$).
The analysis of both tables showed that the accession No. 1, 7, 31 had the largest fresh and air-dry biomass.
The results showed that in 2014 the average fresh biomass was 195.08 g per plant (Table 5).

Table 5

Fresh biomass of oregano accessions in 2014, g per plant

Accession number	Interval
4, 12, 23	Less than 50
2, 11, 14, 15, 21, 24, 32, 36, 38, 42	50-100
16, 17, 19, 22, 25, 26, 30, 32, 34, 37, 44	100-200
6, 10, 20, 29, 40, 45	200-300
1, 3, 5, 7, 9, 13, 18, 27, 28, 31, 35, 39, 41, 43	More than 300

The largest fresh biomass (more than 300 g per plant) had 14 accessions, it was the least (less than 50 g per plant) for 3 accessions. The majority of accessions had the results from 50 to 200 g per plant. The accession No. 31 had the biggest result (495.10 g per plant). The accession No. 23 had the least result (12.61 g per plant). The variability between accessions was significant ($p<0.05$), between plants of each accession it was non-significant ($p>0.05$).
In 2014, the average air-dry biomass was 77.96 g per plant (Table 6).

Table 6

Air-dry biomass of oregano accessions in 2014, g per plant

Accession number	Interval
4, 23	Less than 10
11, 12, 14, 15, 19, 21, 22, 24, 25, 32, 34, 36, 38, 42	10-50
1, 2, 6, 16, 17, 18, 20, 26, 30, 33, 35, 44, 45	50-100
3, 7, 10, 27, 28, 29, 37, 39, 40, 41, 43	100-150
5, 9, 13, 31	150-200

The accessions No. 5, 9, 13, 31 had the largest air-dry biomass (more than 150 g per plant), but 2 accessions had the least air-dry biomass (less than 10 g per plant). The majority of accessions had the results from 10 to 150 g per plant. The accession No. 7 had the highest air-dry biomass (194.07 g per plant). The accession No. 23 had the least air-dry biomass (4.51 g per plant). The variability between accessions was significant ($p<0.05$), but between plants of each accession it was non-significant ($p>0.05$).

The analysis of both tables showed that the accession No. 5, 9, 13, 31 had the largest fresh and air-dry biomass. The data statistical analysis showed that the variability between years was significant ($p<0.05$).

The research of fresh and air-dry biomass is still innovative in our country. At this moment there are no published results of local researchers about this topic in the scientific literature. The only research on biomass had been made in 2011 in the Laboratory of Cultivated Plants and Apilogy, using oregano accessions from the *ex situ* collection in 3 repetitions. The biomass had been explored on oregano accessions that were 4 year`s old. The received data was not published, but they could be used as an orienteer for future studies. The average fresh biomass was 115.31 g per plant. It is necessary to explore the dynamic of biomass in future. It is possible that 4-year-old plants` weight is not maximal and it could be influenced by process of aging of accessions.

In Poland, the average fresh biomass of 1-year-old oregano was 168.1 g per plant, but the average dry biomass was 55.0 g per plant. The average fresh biomass of 2-year-old oregano was 181.9 g per plant, but the average dry biomass was 55.2 g per plant [3]. These results are higher than results that are presented in this research. However, in Italy the average fresh biomass of 1-year-old oregano varies from 116 g per plant [5] to 1269.0 g per plant [11].

By Marzi, the photoperiod influences the growth and the floral differentiation: plants grown under conditions from 12 to 16 light-hours per day enter the full floral differentiation stage around the sixtieth and the ninetieth day of cultivation respectively, plants grown under conditions less than 12-hour daylength are more vigorous with a larger leaf area and a greater plant total dry weight [5]. Azizi et al. found out that the deficiency of water in the soil caused the reduction of oregano plant weight [12]. These statements can be checked for Latvian oregano in the future.

By Marzi, oregano losses of biomass are often encountered after the second mowing in autumn, whenever cuts have been made very close to the ground and frost was experienced [5]. The criteria of right cutting of Latvian oregano should be created.

By Marzi, highest yields are those obtained in the second year with two cuts: in June-July or at the end of October [5]. The practical experience showed that agrometeorological conditions don`t allow to have two identical cuts of oregano per year in Latvia. The exact time of general cut depends on accession`s biology. Usually it starts at the end of June and finishes in August. It is possible to make the 2nd cut in September, but the economical profit is quite minimal.

CONCLUSIONS

The variability of biomass between years and between accessions is significant, but the variability between plants of each accession is not significant.

The previous recommendation is to cultivate the accessions No. 5, 9, 13, 31 in agrocenosis as the most productive.

The dynamics of biomass should be researched. It is necessary to make recommendations for farmers about the optimal parameters of cutting.

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RESPONSE OF *BRASSICACEAE* MICROGREENS TO SUPPLEMENTAL UV-A EXPOSURE

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Abstract. *Low levels of UV-A irradiance increase the content of various plant phytochemicals which have human health-promoting activity. However, there are still little data about supplemental UV-A irradiance in different lighting systems used for plant growing. Therefore, the goal of our study was to investigate the influence of supplemental UV-A light-emitting diodes (LEDs) irradiation for the basal solid-state lighting system indoors and for high pressure sodium lamps (HPS) in the greenhouse on the growth and phytochemical contents of Brassicaceae microgreens plants. The mustard (Brassica juncea L. 'Red Lion'), red pak choi (Brassica rapa var. chinensis 'Rubi* F_1*') and tatsoi (Brassica rapa var. rosularis) microgreens were grown 10 days in peat substrate at 16 h photoperiod, the day/night temperature 21±2/17±2 ºC and relative air humidity – 50-60%. Two experiments were performed: (1) evaluation of the effects of 366-, 390-, and 402- nm UV-A LEDs supplemental to the standard 447-, 638-, 665-, 731- nm set of LEDs indoors and (2) evaluation of the effects of 390 nm UV-A LEDs supplemental to HPS lamps in greenhouses. UV-A photon flux density (PFD) indoors was 12.4 µmol* m^{-2} s^{-1} *and total photosynthetic photon flux density (PPFD) was ~300 µmol* m^{-2} s^{-1}*. UV-A PFD in greenhouse was ~13.0 µmol* m^{-2} s^{-1} *and total PPFD in the greenhouse was ~125 µmol* $m^{-2}s^{-1}$*. Our results revealed that the effect of UV-A supplemental irradiance on phytochemicals content was species dependent. The most obvious positive effect of supplemental UV-A irradiation was detected in red pak choi microgreens. Almost all supplemental UV-A irradiation treatments indoors and 390 nm UV-A irradiation in greenhouse resulted in higher DPPH free radical-scavenging activity, content of total phenols and anthocyanins, ascorbic acid, α-tocopherol, lutein and β-carotene. Such illumination indoors caused the increase of red pak choi leaf area, but decreased it under greenhouse conditions. Different supplemental UV-A irradiation had a positive effect on one or another phytochemicals content of other microgreens. Our findings indicated that it is worth to use supplemental UV-A LEDs for improving nutritional quality of Brassicaceae microgreens.*

Key words: *growth, light- emitting diodes, microgreens, phytochemicals, UV-A irradiance.*

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PHYSIOLOGICAL CHARACTERISTICS ON *SPINACIA OLERACEA* L. SUBJECTED TO SUBSTRATE MOISTURE AND UV-B RADIATION

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Abstract. *The influence of substrate moisture and different dosages of UV-B radiation on spinach antioxidant phytochemical constituents was studied. Spinach (Spinacia oleracea L.) cv. 'Andromeda H' and 'Matador' were the objects of this study. Experiment was conducted in closed growth chambers of controlled environment at the Institute of Horticulture, Lithuanian Research Centre for Agriculture and Forestry. Plants were placed in different growth chambers at 18/13°C day/night temperature and 12 h photoperiod. High-pressure sodium lamps (SON-T Agro, Philips) were used for illumination (150 µmol* m^{-2} s^{-1}*). Spinacia oleracea plants after 21 days for germination were grown in normal (~40%) and drought (<10%) substrate. After 7 days substrate moisture influence plants were exposed to 0* kJm^{-2} day^{-1}*, 1* kJm^{-2} day^{-1} *and 2* kJm^{-2} day^{-1}*, UV-B for 1 day. Analyses were made after 8-days of substrate moisture and UV-B radiation exposure. UV-B radiation (290-320 nm) was provided by UV-B fluorescent tubes (TL 40W/12 RS UV-B Medical, Philips). Different combinations of investigated factors had a significant influence on changes of spinach physiological indices. The lack of substrate moisture reduced the leaf area, fresh and dry biomass accumulation in the investigated species spinach, but under drought conditions increased accumulation of chlorophylls a, b and carotenoids. Spinaches of both species exposed to drought conditions and UV-B radiation have accumulated a larger amount of phenolic compounds and ascorbic acid, depended on their species and UV-B dose.*

Key words: *ascorbic acid, chlorophylls, carotenoids, phenolic compounds, spinach.*

THE EFFEC TO FLIGHT-EMITTING DIODES ILLUMINATION SPECTRA ON GROWTH OF SWEETPEPPER (*CAPSICUM ANNUUM* L.) TRANSPLANTS

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Abstract. *The objective of our studies was to evaluate the growth of sweet pepper transplants, cultivated under various combinations of light-emitting diodes (LEDs) and high-pressure sodium (HPS) lamps. Pot experiments were carried out in the phytotron complex of Institute of Horticulture, LRCAF. Sweet pepper cultivar 'Reda' (Capsicum annuum L.) was investigated. During transplants cultivation, photoperiod of 18 h was maintained, the day/night temperature – 22/18°C and relative air humidity – 50-60%. A system of five high-power, solid-state lighting modules with basal 447 (blue)-, 638 (red)-, 669 (red)-, 731 (far red)- nm and supplemental 380 (UV)-, 595 (yellow)-, 622 (orange)-, 520 (green)- nm LEDs was used in the experiments. For comparison, sweet pepper transplants were grown under the illumination of high-pressure sodium lamps SON-T Agro (Philips,USA). The generated photosynthetic photon flux density (PPFD) of each type of solid-state modules was 200 µmol* $m^{-2}s^{-1}$.

Our investigations revealed that the growth of sweet pepper transplants was enhanced under supplemental yellow (595 nm) light in the high-power solid-state lighting modules with the main blue, red and far-red LEDs. Supplemental yellow light increased leaf area, leaf dry weight, hypocotyl diameter, but caused elongation of sweet pepper transplants. Such LED illumination had positive effect on development and photosynthetic pigments accumulation. Development of innovative technologies for sweet pepper transplants cultivation achieve a good quality and optimal photosynthetic pigment accumulation necessary with the main lights supplemented with yellow light. Supplemental UV-A (385 nm), green (520 nm) and orange (622 nm) light was not suitable for the growth of sweet pepper transplants.

Key words: *growth, illumination spectrum, photosynthetic pigments, solid-state lighting, sweet pepper transplants.*

THE EFFECT OF BLUE LIGHT DOSAGE ON GROWTH AND ANTIOXIDANT PROPERTIES OF *BRASSICACEAE* MICROGREENS

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Abstract. *Light-emitting diodes (LEDs) are an efficient light source for plant growth and development, and can be easily controlled in artificial growing environments. The impact of blue LED light intensity on plant growth parameters and antioxidant capacity of red pak choi (Brassica rapa var. chinensis 'Rubi* F_1*'), tatsoi (Brassica rapa var. rosularis) and mustard (Brassica juncea L. 'Red Lion') microgreens were investigated. Plants were cultivated within 16-h photoperiod, 21±2/ 17±2 ºC (day/night), 50-60 % relative humidity in growth chamber for 10 days after sowing. Total photosynthetic photon flux density (PPFD) was ~300 µmol* m^{-2} s^{-1}*. Five dosages of blue (447 nm; 0, 25, 50, 75, 100 µmol* m^{-2} s^{-1}*) in combination with red (638 nm; 665 nm) and far red (731 nm) LEDs were tested. Results showed that microgreens treated without blue light were significantly elongated than plants treated with ~50-75 µmol* m^{-2} s^{-1} *blue light dosages. The effect of blue light on antioxidant properties differed depending on microgreens species. The small addition (~25 µmol* m^{-2} s^{-1}*) of blue light was more suitable for higher contents of total phenols in mustard and red pak choi microgreens, and ascorbic acid synthesis in tatsoi. The ~75 µmol* m^{-2} s^{-1} *blue light dosage resulted in significantly higher DPPH free radical – scavenging activity and total anthocyanins contents in red pak choi and tatsoi microgreens, respectively. The highest blue light dosage (~100 µmol* m^{-2} s^{-1}*) led to significantly increased accumulation of total phenols in tatsoi. These results showed that supplemental blue light can be strategically used to enhance the nutritional value and inhibit elongation of microgreens. Targeted management of the blue light irradiance in combination with other LEDs may lead to maximized plant production and nutritional quality of young green vegetables grown in controlled environments.*

Key words: *light- emitting diodes, blue light, microgreens, controlled environment, antioxidants.*

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PERFORMANCE OF APPLE STORED FOR LIMITED TIME IN SIMPLE FACILITIES

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Abstract. *The experiment was done at Latvia University of Agriculture, Jelgava, in year 2014. An objective of the experiment was to test performance of apples during limited time storage in simple facilities in regimes not optimal for apple storage. To test this fruit from three apple cultivars: 'Sinap Orlovskii', 'Belorusskoe Malinovoe' and 'Lobo' on rootstocks MM106 and B9 were harvested in 3 harvesting times with 8-days difference. The maturity level at the harvesting time were detected by iodine-starch test, soluble solids content and flesh firmness test and Streif index calculated out of these measurements. Apple were stored in cellar without cooling and active ventilation, and with high air moisture. Average temperature during storage was 8°C, dropping from +13°C to +3°C following outside temperature. The lowest fruit mass loss (caused by evaporation, microbiological and physiological damage etc., not specified in this experiment) for 'Sinap Orlovskii' on both rootstocks B9 and MM106 (7.9 and 4.4%, consequently) were in the latest term with Streif indexes 0.23 and 0.12, consequently. The cultivar 'Belorusskoe Malinovoe' performed best when harvested in middle time with Streif indexes 0.36 and 0.17 for rootstocks B9 and MM106; and their mass loss were 3.9 and 4.6, consequently. In total, cultivar 'Belorusskoe Malinovoe' performed better than the other tested cultivars in all harvesting times. The cultivar 'Lobo' had high mass loss (21-49%) and we presume it was harvested in too high maturity stage already in the first harvesting time (Streif index 0.15-0.06). Pattern of soluble solids was quite similar – it slightly increased during storage for the best times (described previously) and decreased for too late harvested fruits. Fruit firmness was higher for fruits on rootstock B9 for all cultivars. It can be concluded that cultivars, which are not very susceptible to physiological disorders during storage, can be stored for limited time also in cheap storage facilities, if the proper harvesting time is used.*

Key words: *Apple, cultivars, rootstock, storage, mass loss.*

INTEGRATED PEST MANAGEMENT

BOTANICAL DIVERSITY – AN UNEXPLOITED RESOURCE FOR PLANT PROTECTION

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Abstract. *Sustainable insect pest management is often focused on using crop cultivars that are tolerant or resistant to pest attack. However, resistance breeding against aphids has not been sufficiently successful and, in addition, insect-pests can break this plant resistance. Furthermore in modern crop production, crops fields are planted with single genetic varieties, allowing insect pests to spread easily from plant to plant reducing crop yield. Plant biodiversity within crops, such as plant species mixtures (intercropping) and variety mixtures, has been shown to improve ecosystem processes and function, including insect pest management, productivity and system stability. Utilizing this co-existence with other plants, our research provides new evidence that plants interact with each other by the release of volatile signals, which have implications for neighbouring plants. The results of our investigations show that these chemical interactions between plants have effects on biomass allocation [1], leaf temperature [2], plant volatile emission [3], aphid settling responses [4]-[6], and searching behaviour of aphid natural enemies [7],[8]. However, the effects of plant chemical interactions on aphids and their natural enemies depend on botanical composition. In a recent study it was found that older barley cultivars were generally more frequently affected by volatiles than modern cultivar [9]. Certain cultivars respond to volatiles from other cultivars more frequently than others, showing that the responses are specific to certain cultivar combinations [4],[5]. Also interactions between barley and certain weed species have been found to be species dependent [10]. This indicates that the interaction between the emitting and receiving plants works in a lock and key fashion, and the exact dynamics of this interplay are still to be discovered. Our results show that insects such as herbivores and their natural enemies are closely adapted to plant physiology and are highly sensitive to plant responses induced by volatiles. The results stimulate discussion on different farming approaches for improved effectiveness in controlling pests including aphids.*

Key words: *cultivar mixture, induced resistance, pest management, plant-plant interaction, volatile signals.*

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THE ASSESSMENT OF PREVIOUSLY UNAPPLIED FIELD METHOD FOR RESEARCH ON GROUND BEETLES AS INDICATORS OF INTEGRATED PEST MANAGEMENT

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Abstract. *Researches around the world show that ground beetles (Coleoptera: Carabidae) can serve as bioindicators of integrated pest management (IPM). During 2012-2014 in Latvia, research on possibility to use ground beetles as indicators of IPM in winter wheat was occurring using previously unapplied field method – a grid of sample plots with well-known field history. Place of research was Research and Study farm 'Peterlauki' (56°30'39.38''N; 23°41'30.15''E). Totally 24 sample plots (0.3 ha), separated from each other and near crop fields by 2.5 m wide stripes of land covered with vegetation, were arranged in four rows in the grid. The main soil treatments were conventional ploughing (0.22-0.23 m) with mouldboard plough and shallow tillage (0.10-0.11 m) with disc harrow for each two rows of sample plots. Different cereals, rapeseed and beans used to be drilled in sample plots to provide different crop rotations. Twelve winter wheat sample plots had been used for ground beetle studies every year. Ten pitfall traps were placed in 30 m long cornerwise transect for collecting beetles in each sample plot. Exposition of traps started in spring and lasted till the cutting of winter wheat every year. Results of data analyses showed that abundance and biodiversity parameters of ground beetles significantly differ among differently managed sample plots. It means that the beetles prefer to stay inside more suitable habitat and do not equally disperse among closely located sample plots covered with the same crop. It allows concluding that the grid of 24 sample plots is useful field method for research on ground beetles as indicators of agroecological factors within winter wheat and probably other cereal crops. It is also because the grid of sample plots occupies comparably small territory, and it is easy to vary agroecological conditions in every plot during the field studies.*

Key words: *Carabidae, pitfall traps, sample plots.*

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SEARCHING FOR THE CAUSE OF CLOVER FATIGUE

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Abstract. *There is little knowledge about the situation concerning clover fatigue in Norway. Clover is important in organic farming systems and problems with growing legumes will influence organic farming negatively. Both nematodes and fungi can cause clover fatigue. Plant parasitic nematodes were present in samples taken on organic farms in Norway 2011-2012. In 2014 clover plants and soil from 11 farms in Mid-Norway were analysed for both nematodes and fungi. All samples were infected with root rot Fusarium spp., mostly F. avenaceum. Plant parasitic nematodes were found in soil from all samples. Eight nematode groups were present. Spiral nematodes were the most common and abundant group; present on all the farms. No strong correlations were found between numbers of nematodes in the soil and the degree of Fusarium root rot or percentage of clover. However, the least severe root rot was found in the youngest leys.*

Key words: *Organic farming, clover fatigue, nematodes, Fusarium spp.*

INTRODUCTION

Before chemical fertilisers were widely used, different clover species were common in leys. However, early disappearance of the clover, now called clover fatigue, was a serious problem. In addition to abiotic winter damages, various diseases and pests, such as the clover rot fungus, *Sclerotinia sclerotiorum* and the stem nematode (*Ditylenchus dipsaci)*, were known to cause low persistence of clover in the leys in Norway [1],[2]. Sundheim reported that severe injuries in red clover roots during the summer were mainly caused by *Fusarium* species [3]. Nowadays, there is little awareness about clover fatigue. Lately, no systematic surveys have been done regarding the situation in Norway [4].
Legumes, such as clover, provide a major source of nitrogen in organic farming systems, and help to maintain soil fertility. The soil structure is also improved by the roots and biomass of clovers. Organic farming systems have been intensified in the past ten years. On a number of farms, clovers are frequently included in the crop rotation. Recently, some Norwegian organic farmers have noticed a decrease in the amount of clover in the ley and even a reduction of the total harvest. In Sweden, severe injuries caused by *Fusarium* root rot were found to be widely distributed on clover plants in organic leys [5]. In Finland, as part of a project to improve the profitability of organic milk production by increasing the efficiency of red clover cultivation, the fungal species composition and prevalence, and genetic variation and pathogenicity of clover rot (*S. trifoliorum*) and *Fusarium* spp. were studied [6]. The most common *Fusarium* species associated with red clover root rot was *Fusarium avenaceum*. Intensive use of clover in organic farming systems and a warmer climate are factors that indicate a need for attention to increased occurrence of diseases and pests in clover [7]. Problems with growing legumes will influence the nitrogen supply and economy in organic farming negatively.
Different species of fungi and nematodes can cause clover fatigue. Few cultivars are resistant to these organisms, so knowledge on the occurrence of fungi and nematodes is essential for effective crop rotations. In a preliminary study, samples from fields with clover/grass ley were taken on organic farms in different parts of Norway. The samples, taken 2011-2012, demonstrated the presence of different plant parasitic nematodes. In soil from 6 farms in different parts of Norway the following groups and species of plant parasitic nematodes were detected: Stunt nematodes (*Tylenchorhynchus dubius*, *T. maximus* and *Merlinius* sp.), spiral nematodes (*Helicotylenchus canadensis*, *H. pseudorobustus* and *Rotylenchus* sp.), root lesion nematodes (*Pratylenchus crenatus* and *P. fallax*), ring nematodes (fam. *Criconematidae*), pin nematodes (*Paratylenchus* sp. and *P. bukowinensis*), needle nematodes (*Longidorus elongatus*), stubby root nematodes (*Paratrichodorus pachydermus*) and cyst nematodes (*Heterodera trifolii*) [8].
In the present study, we examined the presence of fungi on red clover plants and plant parasitic nematodes in the soil in the root zone of the clover plants.

MATERIALS AND METHODS

Soil, roots and root necks of red clover plants were collected from 11 organic farms in Trøndelag and Nordmøre, in Mid-Norway. On six of the farms the crop rotation consists of grass/clover leys, on the other farms the crop rotation consists of both grass/clover leys and cereals. The samples were taken from grass/clover leys on both sandy soils, clay and moraine soil. The leys were from one to five years old.
The samples were collected on 1st-3rd September, week 36 in 2014. The samples for fungal analyses were rinsed in running water and transported to Bioforsk Plant Health where they, after splitting lengthwise with a scalpel, were incubated on moist filter paper in a humid atmosphere at 20°C. Symptoms of root rot, assessed as lesions on root surface and internal root necrosis and decay (0 = no attack, 3 = severe attack), and fungal growth, were observed in week 37 and 38. Pieces from roots with symptoms of root rot were surface disinfected and placed on agar (PDA) September 19th and assessed for fungal growth three and five days later.
The samples for plant parasitic nematode analyses included clover plants with roots and soil. The soil samples were extracted by the Seinhorst elutriator at Bioforsk Plant Health [9]. Plant parasitic nematodes were identified to family, subfamily and generic level in Leica M10 stereo microscope.

RESULTS AND DISCUSSION

All samples were infected with root rot *(Fusarium* spp.*)*, mostly *F. avenaceum.* On plants from three of the farms the infection was severe, with dark rot in the root neck and inside the roots. Two of these farms had no crop rotation with cereals, while on the third farm the samples were taken from a five year old grass/clover ley, where also the clover proportion was the lowest recorded among the fields sampled in this study. Plants from two fields with low root rot occurrence (farm no 1 and farm no 7) were among the farms with the highest clover proportion and the youngest leys. This is in agreement with a previous Norwegian survey showing more necrotic roots of older plants than roots from one year old plants [3]. No signs of clover rot *(S. trifoliorum)* were detected in the observation period. The reason for this might be that damage from clover rot is most visible in the spring, when damaged plants can be seen and black sclerotia can be found around the root necks of infected plants.
Plant parasitic nematodes were found in soil samples from all farms. The material contained eight nematode groups: *Tylenchus sensu lato*, stunt nematodes (*Tylenchorhynchus* spp.*), root lesion nematodes (Pratylenchus* spp.*), spiral nematodes (*fam. Hoplolaimidae), pin nematodes (*Paratylenchus*), ring nematodes (subfam. Criconematinae), stubby root nematodes (fam. Trichodoridae) and cyst nematodes (*Heterodera* sp).
Spiral nematodes were the most common group and occurred in samples from all farms. The groups *Tylenchus sensu lato* and the root lesion nematodes were observed on 10 farms. Stunt nematodes were present on eight farms, pine nematodes on five farms, while stubby root nematodes and ring nematodes were found on four and three farms respectively. In the soil from one farm a cyst nematode juvenile was detected.
The spiral nematodes were the most abundant group, occurring in high densities in samples from eight farms. In one farm with 5 year old ley, 1030 ind./250ml soil were recorded and the clover cover in this case was only 5-10%. In a young 1 year old ley, which was established after a long cereal cultivation, the numbers of spiral nematodes were 620 ind./250 ml soil with a clover cover of 50-60%. *Tylenchus sensu lato*, root lesion nematodes and stunt nematodes were less common. This was also the case of pin nematodes and ring nematodes. Stubby root nematodes occurred infrequently, but the very high level of 190 ind./250 ml soil was recorded in a 3 year old ley with 20% cover of clover.
In the present material, no strong correlations were found between numbers of nematodes in the soil and the degree of *Fusarium* root rot or percentage of clover.
Like in an earlier study, spiral-, root lesion and stunt nematodes were abundant groups of nematodes in the present material [8]. The numbers of spiral nematodes are similar to the levels observed earlier, while the numbers of root lesion- and stunt nematodes are lower. In the earlier study, samples were collected from more southern locations, which may be a possible explanation for the higher abundance of root lesion and stunt nematodes reported in 2013. It appears that spiral nematodes are abundant and well distributed in most areas of Norway. Population densities of spiral nematodes exceeding 500 ind./250 ml soil may be highly damaging, so the loss of clover cover in the 5-year-old ley may be related to the high nematode numbers. The high population density in the 1-year-old ley may be a pre-crop effect from the prolonged cereal cultivation. These nematodes may, over time, reduce the productivity of the ley, since spiral nematodes have been reported to be associated with growth reductions in red clover in Poland [10].

Spiral nematodes in high densities were also associated with a low percentage of clover in a previous study in Norway [8].

Table 1

Numbers of different nematode groups in samples of 250 ml soil and degree of attack (0: no attack, 3: severe attack) of root rot *(Fusarium* spp.*)* on red clover plants from eleven organic farms in Mid-Norway in 2014.

Farm no.	Age of ley	Tylenchus sensu lato	Stunt nematodes	Root lesion nematodes	Spiral nematodes	Pin nematodes	Ring nematodes	Stubby root nematodes	Cyst nematodes	Fusarium
1	**0**	0	15	13	4	18	0	0	0	**0,5**
2	**5**	28	10	34	1030	0	0	1	0	**3**
3	**2**	78	0	4	315	31	7	0	0	**1**
4	**2**	22	2	6	460	0	0	0	0	**1,5**
5	**5+**	30	0	1	132	0	5	0	0	**2**
6	**2**	10	36	75	25	20	2	190	1	**2**
7	**1**	80	10	2	620	0	0	0	0	**1**
8	**2**	5	0	0	279	0	0	0	0	**3**
9	**2**	55	34	23	215	4	0	2	0	**2**
10	**2**	25	93	29	190	25	0	8	0	**2**
11	**2**	6	10	35	14	0	0	0	0	**3**

Plant parasitic nematodes and fungi are involved in a multitude of interactions related to root damage [11]. For a long time soil-borne fungi have been suspected to interact with nematodes in promoting root decay [12]. There have been no specific studies on the potential complex of clover, involving *Fusarium* root rot and nematodes. Our results did not reveal correlations between nematode densities and degrees of root decay by *Fusarium* spp. It is plausible that the wounds and cavities caused by root-lesion nematodes could enhance a subsequent root infection by *Fusarium* spp., but in this case the restricted material and the high variability in nematode numbers might have obscured such a relationship. Due to the complex dynamics of sequential etiology, where nematode predisposition of plants to pathogen infection may vary in time and space, organism interactions in disease complexes may be difficult to demonstrate in the field [13].

CONCLUSIONS

The results show that damages caused by root rot occurred in plants from all sampled farms and the main *Fusarium* species detected was *F. avenaceum*.

Spiral nematodes were the most prevalent and abundant nematode group, occasionally reaching potentially damaging densities.

In this study, strong correlations between nematode numbers and *Fusarium* root rot could not be detected.

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CROP ROTATION – THE MAIN FACTOR INFLUENCING THE DEVELOPMENT OF WHEAT LEAF BLOTCH

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Abstract. *Lack of crop rotation increases the risk of wheat leaf blotch (caused by Pyrenophora tritici-repentis and Zymoseptoria tritici) development. The aim of the presented study is to clarify the importance of the wheat pre-crop and pre-pre-crop on the development of wheat leaf blotches. A long-term field experiment was established at the Research and Training Farm "Peterlauki" of the Latvia University of Agriculture. The incidence and severity of tan spot were assessed for the whole plant until BBCH 31, for the three upper leaves until BBCH 32-69, and for the two upper leaves until later stages. The obtained results (2012-2014) were categorised according to different crop rotations: 1) pre-crop of wheat (A – wheat; B – alternative crop); and 2) pre-pre-crop of wheat (C – wheat; D – alternative crop). The total impact of disease during the vegetation season was evaluated by calculating the area under the disease progress curve (AUDPC). A rapid development of wheat leaf blotches was observed at the time of flowering except for continuous wheat, where the disease progress started significantly earlier – at the time of booting. Wheat as a previous crop and a pre-previous crop significantly increased the severity of tan spot during the whole vegetation season. The influence of the scheme of crop rotation was less important for the development of Septoria leaf blotch; however, a more-than-a-year break between wheat crops decreased the infection level.*

Key words: *Pyrenophora tritici-repentis, Zymoseptoria tritici, pre-crop, pre-pre-crop.*

INTRODUCTION

Wheat production is one of the most important and profitable branches of crop production in Latvia. The consequence of this situation is the increasing proportion of wheat in the structure of sowings. Lack of classical crop rotation increases the risk of the development of harmful organisms, including the causal agents of diseases. Wheat leaf blotches, especially tan spot (caused by *Pyrenophora tritici-repentis*) and Septoria leaf blotch (caused by *Zymoseptoria tritici*), are the most harmful and widespread wheat diseases in Latvia [1]. Tan spot survives in infected wheat residues; after the necrotrophic phase, pseudotechia develop and asco spores are spread by wind. Therefore, crop rotation has been considered as the main factor influencing the progress of this disease [2],[3]. The life cycle of Septoria blotch is different, it is a splash-borne disease, and therefore the main risk factor of disease development is meteorological conditions, specifically – the number of rainy days [4]; however, agrotechnical measures also influence the severity of this disease. Both causal agents of wheat leaf blotches survive mainly in the residues of wheat – for this reason, the amount of primary inoculums depends on the amount of residues from the previous years. Decomposition of residues is a complex and complicated process; it can be influenced by the content of organic matter in soil, the microbiological activity of soil, the spectrum of soil microorganisms, and also meteorological conditions. Empirical observations show that one year is not sufficient time for a complete decomposition of straw and pseudotechia are found also after two seasons of vegetation. Many different investigations have been conducted all over the world regarding crop rotation as an important control measure of wheat diseases, but the results obtained are inconsistent and the importance of the pre-pre crop is not completely evaluated.

The aim of the presented paper is to clarify the importance of the wheat pre-crop and pre-pre-crop on the development of wheat leaf blotches.

MATERIALS AND METHODS

A long-term field experiment was established at the Research and Training Farm "Peterlauki" of the Latvia University of Agriculture in 2008. The trial conditions were very similar to actual crop production conditions; the total plot area was 6 ha, and the area for each treatment was 0.25 ha. Altogether, 12 plots of winter wheat were surveyed each year.

All agronomic measures were applied uniformly, according to the requirements of agronomic practice in Central Latvia in the vegetation season. Foliar fungicide (epoxiconazole 84 g L^{-1} and fenpropimorph 250 g L^{-1}) 1.5 L ha-1 was sprayed at the time of heading in all treatments.

The incidence and severity of tan spot and Septoria leaf blotch were assessed for the whole plant until BBCH 31, for the three upper leaves until BBCH 32-69, and for the two upper leaves until later stages.

The obtained results (2012-2014) were categorised according to different crop rotations: 1) pre-crop of wheat (A – wheat; B – alternative crop); and 2) pre-pre-crop of wheat (C – wheat; D – alternative crop).

The total impact of disease during the vegetation season was evaluated by calculating the area under the disease progress curve (AUDPC) according to the formula:

$$AUDPC = \sum_{n-1} \left[\frac{X_1+X_2}{2} * (t_1 - t_2)\right],$$

where AUDPC – area under the disease progress curve; n – number of assessments; x – severity of disease at the time of assessment; t_1-t_2 – period of time between assessments.

For statistical analyses of the total impact of the diseases, expressed as the value of AUDPC, a three-factor ANOVA was performed, which included the year factor and the crop and pre-crop factors. The crop and pre-crop factors were analysed in different ways: two factors separately, and as two-factor combinations. Factors "crop and pre-crop rotations" were combined into four groups: wheat after wheat, wheat after other pre-crop, other crop after wheat, and other crop after other pre-crop.

The factor was considered statistically significant when $p<0.05$.

RESULTS AND DISCUSSION

The first symptoms of wheat leaf blotches were observed at the time of tillering and stem elongation; during the stem booting, severity of both diseases decreased because the young leaves were not infected. The severity of tan spot was substantially more expressed, especially in continuous wheat sowings (Fig. 1).

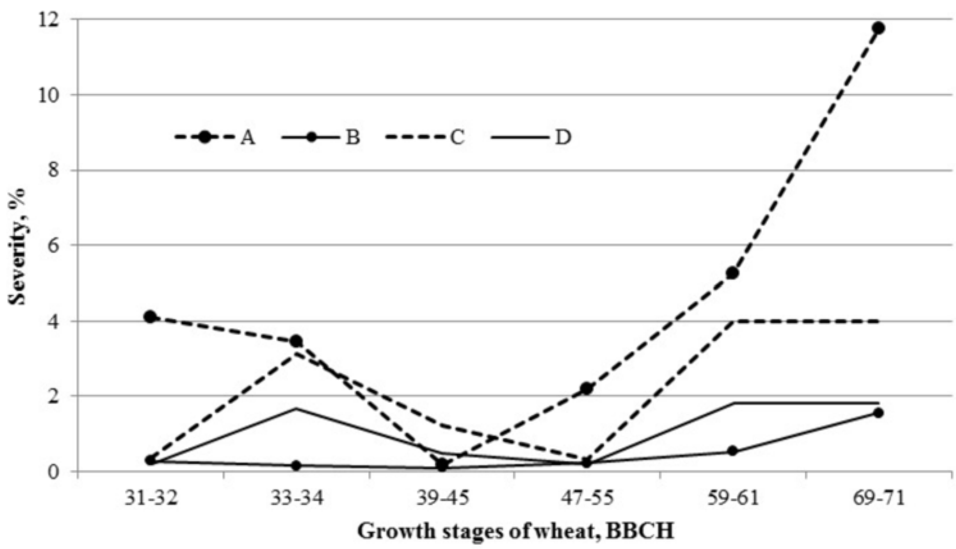

Figure 1. **Dynamics of the development of wheat leaf blotches during vegetation seasons:** A – tan spot in continuous wheat sowings; B – tan spot in the fields after alternative crop; C – Septoria leaf blotch in continuous wheat sowings; D – Septoria leaf blotch in the fields after alternative crop.

A rapid development of wheat leaf blotches was observed at the time of flowering, except for the variant A (tan spot in continuous wheat sowings), when the progress of the disease started significantly earlier – at the time of booting. Similar tendencies of tan spot development during the season of vegetation have been observed also in other experiments in Latvia and Lithuania [1],[5] – the time after winter wheat flowering has been noted as the crucial period of tan spot development.

The values of AUDPC characterize the impact of disease through the whole vegetation season. The development of Septoria leaf blotch was affected by year, but differences in the values of tan spot AUDPC were not statistically significant because variances among the treatments were more considerable (Fig. 2).

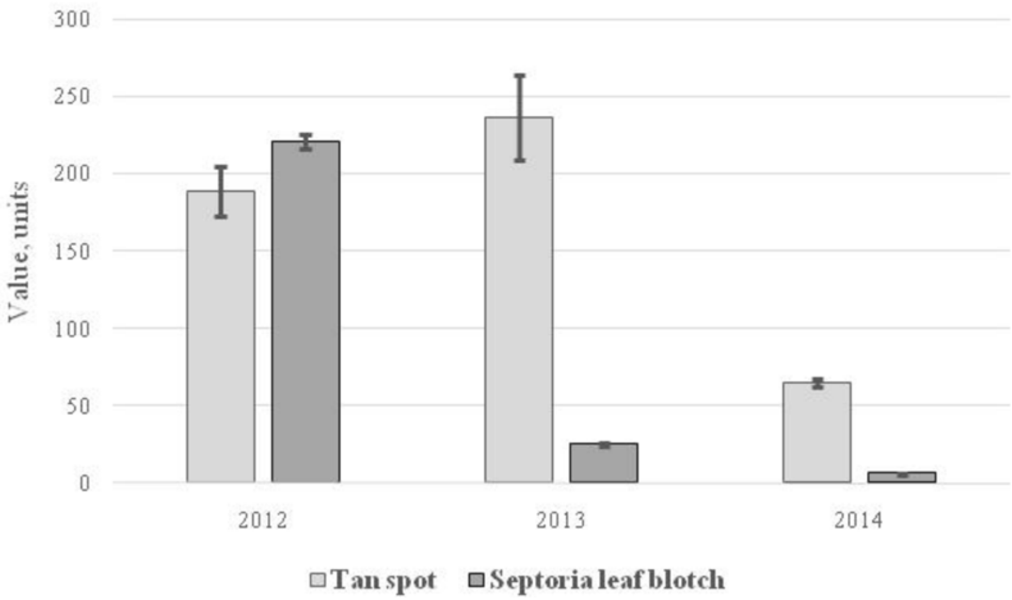

Figure 2. **Development of wheat leaf blotches depending on year.**

The obtained results confirmed the previous observations: distribution of Septoria leaf blotch is closely related to meteorological conditions, but tan spot can progress independently of meteorological conditions of a year [4].

The previous crop and the pre-previous crop significantly influenced the value of tan spot AUDPC ($p<0.05$ and $p<0.1$, accordingly) – see Fig. 3.

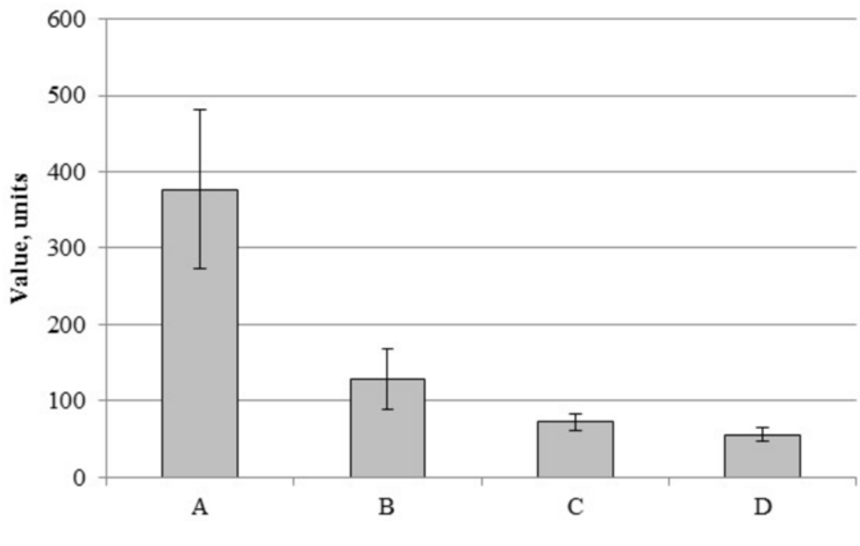

Figure 3. **Development of tan spot, caused by *Pyrenophora tritici-repentis,* depending on the pre-crop and the pre-pre-crop,** where A – wheat after wheat, also the pre-pre-crop was wheat; B – wheat after wheat, but the pre-pre-crop was alternative; C – wheat after the alternative crop, but the pre-pre-crop was wheat; D – wheat after the alternative crop, also the pre-pre-crop was alternative.

Resowing of wheat allows wheat residues to accumulate in the field, which provides favourable conditions for the infection and further development of *P. tritici-repentis*. The highest value of tan spot AUDPC was detected in the fields where wheat had been sown at least for two years in succession. A break of one year between the wheat sowings was not sufficient because also in this variant where wheat was the pre-crop, the level of the disease was higher.

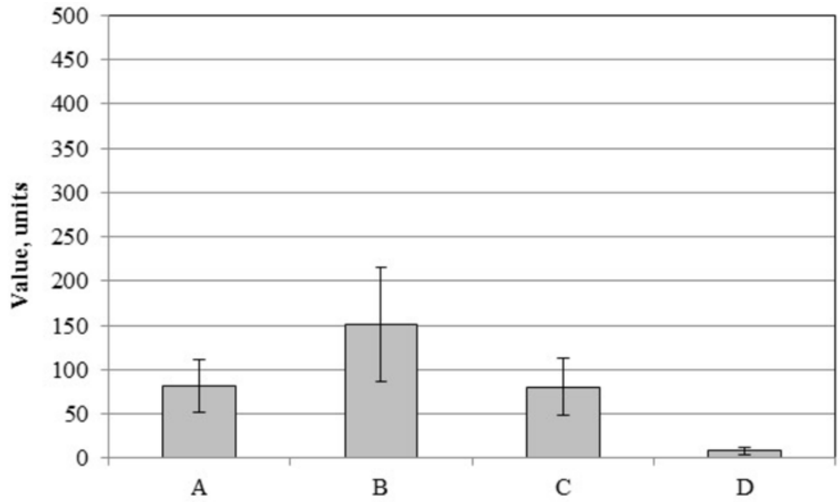

Figure 4. **Development of Septoria leaf blotch, caused by *Zymoseptoria tritici*, depending on the pre-crop and the pre-pre-crop,** where A – wheat after wheat, also the pre-pre-crop was wheat; B – wheat after wheat, but the pre-pre-crop was alternative; C – wheat after the alternative crop, but the pre-pre-crop was wheat; D – wheat after the alternative crop, also the pre-pre-crop was alternative.

The effect of crop rotation scheme on the development of Septoria leaf blotch was statistically insignificant (Fig. 4); however, a more-than-a-year break between wheat sowings essentially decreased the development of Septoria leaf blotch.

Our findings confirm the results obtained previously (Sawinska et al. (2006) – Septoria leaf blotch development varied in successive years [6],[7].

CONCLUSIONS

The scheme of crop rotation significantly influenced the development of wheat tan spot. The severity of tan spot was essentially higher in fields where the pre-crop of wheat was wheat, as well as in fields where the break in wheat sowings was only one year.

The severity of Septoria leaf blotch was slightly influenced by crop rotation, and the level of the disease was significantly lower in fields where the break between wheat sowings was more than one year.

ACKNOWLEDGEMENTS

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THE RESULTS OF A COMPARISON TRIAL OF APPLE SCAB RESISTANT CULTIVARS IN ESTONIA

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Abstract. *A comparison trial of 23 apple scab resistant cultivars was started in spring 2009. The trial was located in southern Estonia at the Polli Horticultural Research Center (58º07`N, 25º32`E). Trees were grafted on dwarfing rootstock B396 and planted in an orchard with the distance 2x4 m (1250 trees/ha). The comparison trial lasted six years (from 2009 to 2014) and provides data for drawing conclusions on disease resistance, winter hardiness, fruit bearing age, and yield of trees as well as the size of fruit. The following cultivars proved to be better suited to Estonian climatic conditions: Belorusskoye Sladkoye, Dace, Elena, and Pamyat Kovalenko. Antei, Dace, and Pamyat Kovalenko stood out with their large yield. The following cultivars produced large fruit: Roberts, Sügisjoonik, Yubilar, Pospekh, Dace, and Antei.*

Key words: *apple, clonal rootstock, fruit quality, growth, yield.*

INTRODUCTION

Climatic and soil conditions as well as consumer expectations about the quality of fruit in an increasingly competitive market are key factors in the selection of species and cultivars in horticulture. Commercial apple orchards in Estonia prefer apple cultivars that are suited for growing during a 170 to 180-day vegetation period and winters that are characterized by intermittent periods of extremely low temperatures (less than 30ºC) and above-freezing temperatures. Furthermore, contemporary environment-friendly growing technology is increasingly aiming for minimal use of pesticides. That is why disease-resistant cultivars and, in case of apple trees, scab-resistant cultivars are preferred. Estonia’s neighboring countries have had some success in breeding disease-resistant apple cultivars: e.g., Latvia [1], Lithuania [2]-[4], Byelorussia [5],[6], and Poland [7],[8]. In Estonia, a comparison trial was initiated in 2009 to determine scab-resistant or scab-tolerant cultivars suited for growing in Estonian climatic conditions. For that purpose, new apple cultivars bred in Estonia’s neighboring countries were collected for a comparison trial aimed at evaluating their performance in the Estonian agroclimatic conditions with minimal use of pesticides.

MATERIALS AND METHODS

The comparison trial included 23 cultivars that were planted in southern Estonia at the Polli Horticultural Research Center (58º07`N, 25º32`E) in spring 2009. Of the total of 23 cultivars, seven were from Byelorussia (Belorusskoye Sladkoye, Darunak, Elena, Imant, Nadzeina, Pamyat Kovalenko, and Pospekh); six were from Poland (Egeria, Ligolina, Lodel, Medea, Odra, and Wars); four were from Latvia (Dace, Edite, Gita, and Roberts); one from the Czech Republic (Rubinola); one from Russia (Yubilar), and two other cultivars (Liberty and Priam). The new cultivars were compared to two cultivars that have been included in the list of cultivars recommended for growing in Estonia: Antei and Sügisjoonik. The trial was carried out in one repetition, with 5 to 10 trees per cultivar. Planting scheme was 2x4 m (1250 trees/ha). The cultivars included in the trial were grafted on a dwarfing rootstock B396. The trees planted in the orchard were two years old. The parameters obtained in the study included yield per tree (kg), average fruit weight (g), the winter resistance of the trees and the extent that the fruit was infected with apple scab (*Venturia inaequalis*). The following measurements were taken to characterize the growth of the trees: trunk diameter 30 cm from the ground (mm) and the length of the leader branch (cm).

The soil type was medium sandy clay, with a pH of 5.5 and a content of K 134 mg/kg, P 156 mg/kg and C org 2.1%. Soil was mechanically clean-cultivated for three years after planting, then grass rows were established between the rows, mowing several times during summer in alleyways grass sward. Herbicide strips were maintained along tree rows and grass sward. The trial orchard was not treated against apple scab.

Climatic conditions were unfavorable in two years out of six (2009/2010 and 2010/2011), when air temperature fell below -30ºC, causing winter damage to trees.

RESULTS AND DISCUSSION

Breeding apple scab resistant cultivars started as a joint project of three US universities already before the Second World War. They found a scab-resistant parent *Malus floribunda* 841. After repeated cross-pollinations they obtained a fifth-generation cultivar Prima. The donors used to obtain the cultivars included in the present trial are Liberty, BM 41497, and SR 0523. The latest releases of the Latvia State Institute of Fruit-Growing include scab resistant (*Rvi6*) cultivars 'Dace', 'Edite', 'Gita', 'Ligita', 'Roberts' and columnar apples 'Inese' (*Rvi6*), 'Duets', 'Baiba', 'Uldis' and 'Zane' [9]. DNA markers confirmed that BM41497 was the source of the gene Vf present in modern cultivars of Belarusian breeding. The cultivars 'Belorusskoye Sladkoye', 'Darunak', 'Nadzeiny', 'Pamyat Kovalenko', and 'Pospeh', which were obtained from BM41497, formed a separate cluster [10]. These cultivars proved to be apple scab resistant in Estonia as well. The cultivars Elena, Egeria, Lodel, and Medea are polygenous to apple scab [7],[8],[11]. Of these cultivars, only Elena exhibited some scab spots on a limited number of apples in a year when conditions were especially favorable for apple scab (2014).

Table 1

The number of winter hardy apple trees in years 2009, 2011, 2014 and tree measurements in 2012

Variety	Number of apple trees			Tree measurements, 2012	
	2009	2011	2014	Ø, mm	Leader branch, cm
Antei	5	5	4	36 b	27 cd
Belorusskoye Sladkoye	10	10	10	27 e	33 b
Dace	10	10	10	30 d	30 bc
Darunak	10	6	0	14 f	22 e
Edite	10	9	8	32 c	32 bc
Egeria	10	9	9	32 c	29 c
Elena	10	10	10	31 cd	38 a
Gita	10	6	6	26 e	25 de
Imant	10	9	9	28 e	40 a
Liberty	5	2	0	18 f	32 bc
Ligolina	10	5	5	33 c	28 c
Lodel	10	5	5	30 d	29 c
Medea	10	3	3	31 cd	27 cd
Nadzeina	5+1	3	2	35 bc	38 a
Odra	10	9	9	37 b	33 b
Pamyat Kovalenko	10	10	10	31 cd	29 c
Pospekh	10	8	8	34 bc	22 e
Priam	10	9	1	17 f	23 de
Roberts	10	5	3	27 e	22 e
Rubinola	10	9	9	43 a	31 bc
Sügisjoonik	10	10	8	32 c	23 de
Wars	10	5	5	36 b	27 cd
Yubilar	10	5	2	35 bc	26 d

Winter hardiness is an important characteristic in selecting cultivars. The harsh winter of 2009/2010 damaged the trunks of young trees. A similarly harsh winter in 2010/2011 damaged the already weakened trees to such a degree that the trees of several cultivars had to be cut back severely or were destroyed (Table 1). In the part of the orchard where trees had grown two years, at least 50% of trees were lost in case of cultivars Yubilar, Ligolina, Gita, and Medea. Trees were cut back severely in case of cultivars Darunak (70%), Priam (70%), Liberty (80%), Lodel (50%), Roberts and Wars (30%), and Rubinola (20%). By 2014, when the orchard was six years old, all trees had survived in case of the following cultivars: Belorusskoye Sladkoye, Dace, Elena, and Pamyat Kovalenko. Insufficiently winter-hardy cultivars had been Liberty, Priam, Yubilar, Medea, Roberts, and Nadzeina. More than 50% of trees were destroyed in case of these cultivars. In case of cultivars Ligolina, Lodel, and Wars, 50% of the trees planted in the orchard were lost. Egeria, Imant, Odra, Antei, Sügisjoonik, and Edite could be considered satisfactorily winter resistant.

Vegetative growth characteristics of trees (trunk diameter and length of leader branch) were measured in the fourth year after planting in the orchard. Trunk diameter of cultivars Darunak, Priam, and Liberty was less than 20 mm (Table 1). These cultivars were severely pruned back due to winter damage. The trees of cultivars Rubinola, Odra, and Wars had the largest trunk diameter (36 to 42 mm). The length of leader branch shows a tree's growth vigor during the vegetative period. Cultivars Imant, Elena, and Nadzeina were most vigorous. The leader branches of cultivars Roberts, Pospekh, Darunak, Yubilar, Gita, and Sügisjoonik had shortest leader branches (22 to 26 cm).

Table 2

The average of yield kg/tree of apple varieties in years 2009 to 2014

Cultivar	Yield, kg/tree						Average yield, kg/tree
	2009	2010	2011	2012	2013	2014	
Antei	3.2	1.0	9.0	10.6	7.9	6.8	6.4 a
Belorusskoye Sladkoe	2.8	0.1	2.4	3.1	6.3	1.7	2.7 c
Dace	1.8	0.6	3.3	5.7	7.2	18.6	6.2 ab
Darunak	0.7	1.6	1.7	0.3	0	-	0.7 d
Edite	0.3	0.2	0.7	1.8	1.9	4.6	1.6 c
Egeria	0.7	0.1	1.3	2.3	4.8	6.4	2.6 c
Elena	2.1	2.0	3.8	5.3	5.5	4.8	3.9 bc
Gita	0.8	1.0	1.8	2.2	8.1	5.6	3.3 c
Imant	0.2	0.1	1.6	3.9	4.5	2.6	2.2 c
Liberty	1.0	0.8	1.5	0	0	-	0.6 d
Ligolina	1.3	0.3	1.8	3.0	1.2	2.8	1.7 c
Lodel	0.5	0.5	2.5	2.2	2.1	4.8	2.1 c
Medea	0.3	0.2	2.7	0.7	1.0	0.5	0.9 d
Nadzeina	1.7	1.2	1.1	2.8	2.7		1.9 c
Odra	0.3	0.2	4.8	2.3	10.6	3.9	3.7 bc
Pamyat Kovalenko	1.9	0.5	6.0	5.4	8.4	4.9	4.5 ab
Pospekh	0.8	0.9	3.0	4.8	5.9	5.3	3.5 bc
Priam	0.9	1.1	2.1	0.1	0.6	1.0	1.0 d
Roberts	0.8	1.1	0.5	3.9	0.1	2.8	1.5 c
Rubinola	0.2	0.2	2.7	4.7	3.2	11.9	3.8 bc
Sügisjoonik	0.5	1.1	1.4	3.8	1.3	2.2	1.7 c
Wars	0.8	0.4	3.3	1.2	4.9	5.7	2.7 c
Yubilar	1.2	0.4	2.1	7.4	9.1	1.0	3.5 bc
Average	1.1 A	0.7 A	2.7 B	3.4 C	4.2 D	4.3 D	

Early fruiting cultivars are preferred in planting commercial orchards. Among control cultivars, Sügisjoonik starts to bear fruits late [12] and Antei is very early fruiting cultivar [11]. Young trees grafted on dwarfing rootstock B396 blossomed during their first year in the orchard. The average yield of the trial cultivars was 1.1 kg/tree in the first year, 0.7 kg/tree in the second year, and 2.7 kg/tree (Table 2). Based on the total yield of the first three years, early fruiting cultivars were Antei (13.2 kg/tree), Pamyat Kovalenko (8.4 kg/tree), and Elena (7.9 kg/tree). The yield of the young trees of most cultivars was between 3.0 and 5.7 kg/tree. However, the yield of cultivars Edite, Imant, Egeria and Roberts was below that level. These differences were explained by biological characteristics of cultivars – the cultivar's genetic potential for formation of flower buds – and the impact of winter damage to the health of young trees.

The yield of the trees increased year by year. The average yield per tree was 3.4 kg/tree in the fourth year and over 4 kg/tree in the fifth and sixth year. Based on the average of six fruit-bearing years, cultivars Antei, Dace, and Pamyat Kovalenko were most productive. The yield of cultivars Roberts, Edite, Ligolina, Nadzeina, Lodel, Imant, Egeria, Wars, and Byelorusskoye sladkoye did not exceed the yield of one of the control cultivars, Sügisjoonik. The yield was the lowest for cultivars Darunak, Liberty, Medea, and Priam. The yield of high-yielding cultivars in the six years exceeded 33 tons/ha. In comparison, in Lithuania, high-yielding apple cultivars on rootstock M26 reached this level already in the fifth year [13].

The largest apples were on cultivars Roberts and Sügisjoonik, accordingly 191 g and 179 g (Table 3). The fruit of the cultivars Yubilar, Pospekh, Dace, Antei, and Nadzeina was larger than the average (134 g) of the cultivars included in the trial. The fruit of cultivars Elena, Lodel, Medea, Ligolina, and Odra was smaller than the average.

Table 3

Average fruit weight (g) in years 2009-2014

Cultivar	Fruit weight, g						Average weight, g
	2009	2010	2011	2012	2013	2014	
Antei	226	181	142	122	140	137	158 abc
Belorusskoye Sladkoye	178	155	150	97	104	112	133 bcd
Dace	186	213	130	131	184	150	166 ab
Darunak	171	129	125	120	-	-	136 bcd
Edite	160	138	134	118	146	132	138 bc
Egeria	144	116	111	120	128	110	122 cde
Elena	100	80	65	69	74	76	77 e
Gita	133	125	132	113	140	147	132 bcd
Imant	124	200	145	116	142	117	141 bc
Liberty	141	119	114	-	-	-	125 cde
Ligolina	96	114	110	101	111	100	105 de
Lodel	93	103	91	106	110	100	101 de
Medea	89	120	115	87	98	100	102 de
Nadzeina	196	142	124	135	191	-	158 abc
Odra	108	113	109	169	90	113	117 cde
Pamyat Kovalenko	146	163	158	109	113	131	137 bc
Pospekh	196	182	178	180	157	127	170 ab
Priam	160	100	100	-	112	108	116 cde
Roberts	236	256	190	162	-	109	191 a
Rubinola	135	105	188	104	111	117	127 cde
Sügisjoonik	240	208	137	178	173	136	179 a
Wars	126	136	131	100	106	113	119 cde
Yubilar	201	275	195	122	120	130	174 ab

CONCLUSIONS

The comparison trial of 23 apple cultivars that lasted for six years (2009 to 2014) allows to draw some conclusions on disease resistance, winter hardiness, early cropping, productivity and size of fruit. The cultivars that proved to be best adapted to the Estonian climatic conditions were Belorusskoye Sladkoye, Dace, Elena, and Pamyat Kovalenko. Early cropping cultivars were Antei, Pamyat Kovalenko, and Elena. The cultivars with highest yield were Antei, Dace, and Paymat Kovalenko. The cultivars with largest fruit were Roberts, Sügisjoonik, Yubilar, Pospekh, Dace, and Antei.

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INCREASED INFESTATION OF AGRICULTURAL LAND WITH WILD OAT (*AVENA FATUA* L.) IN LATVIA AS RELATED TO VARIATION OF SEED MORPHOLOGY AND GERMINATION

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Abstract. *Monitoring of Avena fatua was performed in 2013 and 2014 to detect a level of infestation in agricultural fields. In 2014 high infestation level was detected in 17% of the surveyed parishes, mostly in areas with large proportion of agricultural land. Seed samples were collected from 177 locations in different regions of Latvia. Variation in seed morphology was detected among the populations according to size, color, hair intensity and awn length. Seed germination tests showed differences in germination of seeds with different morphology, collected from different locations and in various years. Seed scarification promoted A, fatua germination in the laboratory conditions. Field emergence trials were performed in 2013 and 2014. Prolonged emergence of A. fatua in the field is an additional obstacle for successful control of this weed. Continuous monitoring and further studies are required to acquire information on possible hybridization of A. fatua with A. sativa, as well as on a development of herbicide resistance in A. fatua populations.*

Key words: *Avena fatua, weed monitoring, seed morphology, germination.*

OCCURRENCE OF CARROT DISEASES IN LATVIA

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Abstract. *Carrot is one of the most popular and profitable vegetables grown in Latvia, nevertheless there is a lack of knowledge regarding carrot diseases. Diagnosis and identification of pathogens is one of major factor for successful disease control. Field observations of carrot disease development during vegetation and storage seasons and diagnostic pathogens were carried out at Pure Horticultural Research Centre and Institute of Soil and Plant sciences of LLU during the years 2008-2012. Diseases were determined according visual symptoms and microscopic features of fruiting bodies and spores. Potato dextrose agar was used for isolation and identification of pathogens.*

Alternaria leaf blight of carrots (caused by Alternaria dauci) dominated in all observation period, but in 2011 and 2012 also incidence of Cercospora leaf blight (caused by Cercospora carotae) was high. Both above mentioned diseases under field conditions of Latvia considerably reduce the leaf photosynthetic area, therefore carrots are more difficult to harvest with a mechanical harvester and carrot yields can reduce significantly. In the year 2010 the white rot (caused by Sclerotinia sclerotiorum) also was identified on carrot foliar in the field.

During storage, assessment of carrot diseases was done once in a month in all investigation years. The identified pathogens belonged to different species – Thielaviopsis basicola (black rot), Penicillium spp. (blue-green mold), Rhyzopus spp. (rhyzopus woolly soft rot), Phoma apiicola (phoma root rot), Phytophthora spp. (phytophthora root rot), Fusarium spp. (fusarium dry rot), Alternaria dauci (black rot) and S. sclerotiorum (cottony rot). The number of infected carrot roots was minimal and yield losses were not significant. The disease development during storage depends more on the microclimate in the storage facilities.

Key words: *carrot disease, Alternaria, Cercospora, Sclerotinia.*

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MAIZE (*ZEA MAYS* L.) LEAF DISEASES IN LATVIA

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Abstract. *Maize has important role in agriculture of Latvia. Area planted with maize has increased rapidly from 5.1 thousand ha in 2008 to 20.6 thousand ha in 2012. Maize in Latvia is mostly used as forage (silage) and as raw material for biogas production. Some farmers in despite of temperate climate harvest maize for grain. In regions where moderate temperatures and relatively high humidity during growing season are typical the most important leaf disease is Northern Corn Leaf Blight (NCLB). The same weather conditions favour the development of Northern Corn Leaf Spot (NCLS). In previous studies on maize leaf diseases it has been found that NCLB is present in Latvia and if the conditions are favourable for disease the use of fungicides can significantly reduce symptoms of disease and increase the yield and quality of production. (Treikale, Vilcans, Javoisha, 2012; Treikale et. al., 2014). NCLB is caused by Exserohilum turcicum Leonard & Suggs (Helminthosporium turcicum Pass.), which is the teleomorph of Setosphaeria turcica (Lutterell) Leonard & Suggs. Favourable conditions for NCLB development are temperatures between 20 and 25°C, relative humidity from 90 to 100% and low luminosity. NCLB can cause serious yield losses up to 50%. However in studies which confirms such a serious yield reductions artificial inoculation has been used. The aim of study was to evaluate NCLB incidence and severity in different maize hybrid performance comparison trial in Research and Study farm "Vecauce" (latitude: N 56°28', longitude: E 22°53') of Latvia University of Agriculture. Hybrids were arranged in randomized blocks with 4 replications, plot size 16.8 m*^{2} *(4 rows). In this trial 26 different maize hybrids were tested. The trial was carried out in Calcaric Luvic Epigleyic Phazeozem soil (pH KCl – 6.9,* P_2O_5 *– 583 mg kg*$^{-1}$*,* K_2O *– 219 mg kg*$^{-1}$*, organic matter – 3.0%) Pre-crops in trial were maize in 2010, 2011 2013 and sunflower in 2012. Conventional soil tillage technology was used. Planting date was 6th May and planting density 83000 seeds ha*$^{-1}$*. Maize was harvested for silage on 6th October, average dry matter content – 33.5% and average dry matter yield – 18.51 t ha*$^{-1}$*. Observations was started at growth stage BBCH 65-67, the first symptoms appeared at growth stage BBCH 71-73, then assessments of severity were carried out two times on 6th and 18th September. Assessment data were used to calculate area under disease pressure curve (AUDPC). AUDPC data were submitted to analysis of variance to compare means between hybrids. Disease symptoms observed were elliptical lesions initially in grey-green colour, but later tan in colour. The spots weren't restricted by the leaf veins and their size was from 1 to 6 cm. These symptoms are typical for Exserohilum turcicum, but can be confused with symptoms of NCLS (anamorph Helminthosporium carbonum) however the lesions of NCLS usually elongate linearly between the veins of the leaf. Overall the disease severity was low and only in some cases area of leaf damaged was higher than 2%. The slight increase of disease severity was observed between 1st and 2nd (twelve days later) assessment. The average disease incidence on 1st assessment in trial was about 41%, but severity only about 0.5% and on 2nd assessment about 53% and 0.6% respectively. The average AUDPC was 16.34 ± 4.55. AUDPC difference between hybrids was significant. In several studies has been confirmed that susceptibility level of genotypes can be reason for significant differences in leaf disease severity and incidence. The maize hybrids were divided in three groups. The group average AUDPC ± SE (16.34 ± 4.55) includes 11 genotypes from 26. In group of genotypes below average AUDPC ± SE were 9 hybrids. The AUDPC in this group were between 7.80 and 11.73. In group above average AUDPC ± SE were 6 cultivars and here AUDPC was between 23.10 and 30.08. Although severity of maize leaf diseases is not very high in Latvia yet, this can change especially if the total area of maize continues to grow.*

Key words: *temperate, northern, hybrids, NCLB, AUDPC.*

ORGANIC AGRICULTURE

THE ORGANIC SECTOR IN THE NORDIC-BALTIC REGION – WHAT IS ACHIEVED, AND WHAT IS CHALLENGING FURTHER GROWTH?

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Abstract. *This paper compiles statistics for certified organic farmland and organic consumption in the eight Nordic-Baltic countries, and describes main drivers and obstacles, focussing on policy and strategies including organic research. Significant differences are found between the countries, also between countries with relatively comparable climatic and economic conditions. Explanations are discussed. Successful examples, especially Denmark and Sweden, show that organic agriculture is an option for refreshing agriculture in general, when there is a significant political will to support this farming practice.*

Key words: *consumption, policy, premium price.*

INTRODUCTION

Within the Nordic-Baltic (NB) region, production and consumption of certified organic food are quite different between the eight countries (Table 1). The region includes organic frontrunners, but also latecomers. In most countries, public targets for organic agriculture (Table 2) are rather ambitious compared to status. Countries with comparable levels of economic prosperity are highly different in organic consumption, and countries with comparable agricultural conditions are highly different with respect to the proportion of organic farmland. Organic research, understood as scientific activities to support the growth of organic production and consumption, is an important driver for organic growth. Hence, the development of the organic sector, and the role that organic research has played to support this development, is an interesting case to be highlighted by the Nordic Association of Agricultural Scientists (NJF). This paper compares the public targets and the actual extent of organic production (certified farmland) and consumption in the NB countries, and analyses the differences in light of public and political support, not in terms of funding but of political will, arguments and strategies. The aim is to reveal important bottlenecks hampering further growth of the organic sector, and to learn and be inspired from the more successful cases.

EXTENT OF CONSUMPTION AND PRODUCTION

Since the EU introduced a regulation for certification of organic food in 1991, organic agriculture has grown rapidly in most European countries. The EU supports organic and low-input agriculture to protect the environment, ensure high animal welfare, increase biodiversity, support rural development, and not least because of the steadily increasing public demand for organic products. The first European Action Plan was published in 2004, and the second in 2014. In the NB region, Sweden and Estonia take the lead in certified farmland (Table 1). However, the organic production in these countries is dominated by ruminant animal husbandry, as shown by the large proportion of organic farmland used for grass. This may call for a more “active” organic agriculture, producing more food commodities than milk and meat products. Ruminant animal husbandry is common in all the NB countries, but the proportion of organic arable land, here simplistically understood as the share of organic farmland NOT being used for leys, grazing, green manures or energy crops (Table 1 column 8), is somewhat higher in Denmark. It is remarkably high in Lithuania, where a lot of organic cereals are grown for export.

Table 1

National statistics on population [1], prosperity [2], and the consumption and production of organic food [3] for 2012 (population 2010), listed by % certified organic farmland.

Country	Population, mill.	Population km^{-2}	GDP $capita^{-1}$ kEuro 2012, | relative Latvia =100	Organic consumption, % of retail sales	No. of certified organic producers	Certified organic farmland k ha	Proportion of non-arable land, %	Certified land, % of total | relative to consumption
Sweden	**9.3**	27	35.6 | 258	3.9	**5601**	**478**	75	**15.6** | 4
Estonia	1.3	36	17.9 | 130	1.2	1478	144	74	15.3 | 10
Latvia	2.2	56	13.8 | 100	0.2	3496	197	78.5	10.8 | 54
Finland	5.4	19	31.9 | 231	1.6	4322	198	67	8.7 | 5
Denmark	5.5	**130**	32.7 | 237	**7.6**	2651	195	58	7.4 | **1**
Lithuania	3.3	72	16.6 | 120	0.2	2527	157	27	5.4 | 27
Norway	4.9	18	**47.2** | 342	1.2	2590	55	77	5.1 | 4
Iceland	0.3	3	33.5 | 243	2	35	8	98	0.4 | 4

The organic consumption is highest in Denmark, followed by Sweden. It is remarkable that Estonia, with a GDP (gross domestic product) less than half of Norway, has a similar consumption of organic products. It is also remarkable that Denmark has a much lower proportion of certified organic farmland relative to the organic consumption, than any other NB country. Another extraordinary case is Latvia with almost 11% organic farmland, but very low consumption.

POLICY AS DRIVER FOR ORGANIC GROWTH

Public support for organic production and consumption include a range of instruments, ranging from production payments to support for education, training and research and development projects, including market development. The demand side has been especially emphasised in Denmark [15]. In the EU member NB states (all except Norway and Iceland), EU support comes as an additional instrument. In any case, the public support reflects the strategy chosen by leading stakeholders, like industry boards, agricultural ministries and farmers' unions. Public goals for production, partly also consumption, are found in all NB countries (Table 2).

Sweden specified a target for the proportion of organic farmland already in 1996, supported by public payments. A report from the national board of agriculture [4] comes close to a national action plan and is a basis for governmental decisions. The targets will be revised during 2015. The public support is justified by a public recognition of environmental benefits of organic production [4]. The proportion of organic animal husbandry, milk production and arable land is a measure for the environmental status of each county [5]. There is also a significant support for extension activities towards farmers and advisors. Directed national calls with public funding for organic research has been in place since almost 20 years [6], and a coordinating national research centre, EPOK, has been established which also disseminates results towards agricultural and societal stakeholders.

Estonia entered the organic scene about 10 years later. Similar to other Baltic countries, EU support for organic farming has been driving the growth of organic farmland. However, organic processing has not been supported, and is in a serious imbalance with the production. To support domestic production of organic food products, Estonia recently decided not to focus on the proportion of total consumption being organic [7]. Instead, the monetary value of the organic production relative to total Estonian agricultural production should now increase by 50% from 2014 to 2020, and the monetary value of processed organic products by a factor of 3 from 2013 to 2020. Despite the large proportion of certified land, organic production still needs to be increased. Even if most of the area is grassland, milk and meat products are lacking in the market, and the production of fruit and vegetables does not by far fit to demand. Lack of organic processors and small processing volumes are main reasons for the lack of domestic organic food. Conventional processors consider the production volumes and organic food market too small, and the logistics too expensive, to be interested. Hence, significant amounts of organic produce are processed and sold as conventional. This explains the Estonian strategy to increase the competitiveness of organic producers and increase the consumption of local organic food.

Latvia also has a 10-year long history of public support for organic production. The organic consumption is small, but increasing, partly due to the development of organic processing enterprises which have increased from 86 in 2010 to 192 in 2013. As much as 8% of the consumed milk in 2013 was organic. Other important organic products in Latvia are honey, cereals, potatoes, vegetables, eggs and chicken. Processing enterprises receive public support. An ambitious target of 50% organic by 2020 [8] is set for public food procurement in state education, social care and health promoting institutions. Main strategic targets within 2020 are to increase the volume of organic domestic products by 50% compared with 2014, to establish four regional cooperatives covering all Latvia and to establish a long-term research program in organic farming.

Finland was also an organic latecomer, with the first national target published in 2005. However, in recent years the ambitions have been significantly strengthened. The organic sector, along with local food, is supported by several public bodies justified by a public interest for sustainability. In Finland, the Ministry of Environment publishes the targets of organic farmland [10]. The first target called for 10% organic farmland by 2010. Practical guidelines for public catering [11] recommends that organic, vegetable and seasonal food should be served twice a week by 2015. Current targets for 2020 aim at 20% organic farmland, tripling of the organic retail market from 1.3% in 2012 to 4%, and a 20% share of organic food in publicly catered meals [10]. Main bottlenecks are seen to be consumers' uncertainty about the organic value, slowness and small size of the organic sector, bureaucracy, and lack of communication within organic food supply chains [19]. Recently, FORI developed a national research programme for organic food and farming [20].

Denmark published their first national action plan already in 1995, and since then not less than five such plans have been produced (Table 2). The recent plan has one, simple target: to double the organic area compared with 2007, corresponding to 11% of the agricultural area [12]. General targets for the organic sector as developed in former plans are to increase export and public procurement of organic food, based on a collective effort from all ministries. Noteworthy for the Danish organic success is the unified efforts since the mid 80's to treat the organic sector as an evolving industry, in addition to the aim of protecting nature [14]. This is reflected in the large interest for organic production in the Danish Agriculture & Food Council (Landbrug & Fødevarer, Table 2), which represents all domestic farming and food industries including businesses, trade and farmers' associations, including the organic sector. This reflects the importance of agriculture, including organic, as a large export industry in Denmark. One national, public and free certification scheme, the red "Ø" known by a vast majority of Danish consumers, has likely contributed to the high trust in organic produce in this country. Further, a close cooperation between public and non-governmental organisations, willingness among the organic organisations to streamline their interests, and a high support for demand-side stimulating measures have contributed to the success [14]. It is pointed out that a will amongst politicians to engage in the organic sector has been crucial [14]. The establishment of ICROFS to coordinate research in Denmark as well as internationally, has also been important.

Lithuania was first among the Baltic countries to present a national target for organic production [15]. The EU support for organic farming has been a crucial driver for organic growth and called for many farmers to convert their production. The Ministry of Agriculture has prioritised their support for market development activities such as fairs and events for consumers, and scientific research activities. There is an imbalance between the production of organic cereals and livestock, leading to a lack of organic manure. A big amount of organic cereals is exported. There is a need to develop and test appropriate cereal varieties for organic farmers. Main targets for the next period are to support and increase the extent of mixed organic farming, and further to increase the general competitiveness of organic producers and the consumption of local organic food.

Norway was a frontrunner in time along with Denmark and Sweden, presenting their first national target in 1995. However, the similarity stops at this point. Targets are still ambitious, but the political will to achieve them is low, especially since a conservative government was elected in 2013. The action plan has not been revised since 2009. Similar to Iceland, Norway follows EU regulations for organic production and processing as a part of the European Economic Agreement (EEA) since 1994.

Iceland is a latecomer in the organic world, publishing their first national target in 2011 [17]. Caring about their language, they have invented an inspiring term to mention organic agriculture: *lífrænn landbúnaður*. A direct translation would mean life-run land-clothing. Explaining organic as originating from life is a fruitful perspective. In this country, the main barrier to conversion is lack of acceptable sources of plant nutrients, particularly N. There is a shortage of suitable legumes able to fix N at the generally low temperatures.

Table 2

National policy documents (10) and targets for organic agriculture

Country	Publishing year(s) for National Action Plan(s)	Target for organic farmland, % | by year	Target for organic consumption, % | by year PS = public sector	Main drivers, organization(s) and arguments	Coordinating body for organic research, or initiating and disseminating projects
Sweden	1996, 2001, 2012	20 | 2013	PS 25 | 2010	Organic Sweden KRAV, national cert. body Public environmental goals[5], strong animal welfare policy	EPOK, Swedish University of Agricultural Sciences (SLU)
Estonia	2007, 2014	19 | 2020	30 | 2020 (in childcare institutions)	Estonian Organic Farming Platform Healthy, local and tasty food, environment	Estonian University of Life Sciences, Research Centre of Organic Farming
Latvia	2004, 2007, 2011, 2014	15 | 2020	PS 50 | 2020	Latvia Organic Farming Association	Latvia University of Agriculture, State Priekuli Plant Breeding Inst. and State Stende Cereals Breeding Ins.
Finland	2005, 2009, 2010, 2012	20 | 2020 50 | 2030	PS 10 | 2015 20 | 2020 Retailing 3x2012 level by 2020	Ministries (Agr.&For., Envir. and Foreign), Council of the State, Proluomu Association, FORI Clean environment, high quality of domestic food, animal welfare	Finnish Organic Research Institute (FORI)
Denmark	1995, 1999, 2011, 2012, 2015	11 | 2020	PS 60 | 2020[13]	Danish Agriculture and Food Council Organic Denmark Supporting exports, protecting environment	International Centre for Research in Organic Food Systems (ICROFS)
Lithuania	2002, 2015 (in preparation)	5|2006	No specific target	Gaja – Lithuanian Association of Organic Agriculture; LEUA – Lithuanian Association of Organic Farms, Ekoagros – cert. body	Ministry of Agriculture
Norway	1995, 2000, 2003, 2009 [16]	15 | 2020	15 | 2020	Oikos – Organic Norway Cover demand, create sustainable solutions	Bioforsk Organic Food and Farming
Iceland	2011	15 | 2020		VOR-Organic Farming & TÚN-Certification Body	Agricultural University of Iceland

On Iceland, another challenge is EU regulations poorly adapted to Arctic agricultural areas with short growing seasons and very limited growing of cereals, causing a lack of straw for livestock beddings. Slatted floors in sheep houses are common, but further derogations have not been accepted by the EU, and demands for livestock space do not take into account the smaller size of native Icelandic breeds of dairy cattle, sheep, goats and horses. Similar to Norway, there is a lack of organic vision in public and academic bodies. Furthermore, the conversion scheme implemented in 2010 lacks public funding. In practice, no priority is given to the organic sector in spite of the fact that market demand is far above supply in all major food commodities. The steadily increasing demand is met by growing imports from overseas. The technical and social barriers counteract the progress achieved by research, teaching, extension, conversion and development. As opposed to Sweden, Finland and Denmark, organic agriculture in Iceland and Norway has not yet been officially accepted as a means to increase the environmental performance or sustainability of agriculture in general. Neither have the positive consumer aspects been fully realized by policy makers.

THE ROLE OF RESEARCH

Organic research is a prerequisite for organic growth, and a significant amount has been conducted within the NB countries, which except for Iceland all participate in the CORE Organic ERA-net. The CORE Organic projects are an important addition to the larger EU projects that have significantly contributed to the generally advanced status of organic food and farming in Europe as compared to elsewhere in the world. Organic research has increased our knowledge about agroecosystems and how to manage them efficiently, while maintaining a fertile soil and a landscape with high biodiversity. Further, we have gradually developed a better understanding of people's reasons to buy organic food and the benefits of converting public catering to organic. Scientists may find it inspiring to operate within the frame conditions set by the organic principles of health, fairness, ecology and care, commonly operationalised by the EU regulations for organic production. Since this framework reduces the inputs of "quick-fix" purchased products significantly, research may concentrate on the importance of knowledge and competence for management of crop rotations, animal husbandry and farming in general. Within the food service sector, the importance of using local food, making food from non-processed raw materials and increasing vegetable based food while reducing meat, are central topics along with the emphasising the human factor, parallel to the emphasising of a conversion not only of the farm itself, but also of the farmer. However, significant research efforts have also been conducted to test the possible role of inputs better adapted to organic farming systems, such as "efficient" microorganisms, "natural" pesticides and fertilisers made from recycled organic materials. The recent vision of TIPI, the Technology Innovation Platform of IFOAM (International Federation of Organic Agriculture Movements) until 2030 is to develop organic farming in the dynamic span between creating healthy lifestyle and solving global problems [18].

CONCLUSION

Countries like Denmark, Sweden and Finland demonstrate that protection of the environment, and contribution to sustainable development, can be important drivers for organic growth when politicians justify their support for organic agriculture by these arguments, and there is a real will to bring this farming system forwards. Along with Estonia, these countries have also established strong centres for research coordination and dissemination. The Baltic countries struggle to balance better the large proportion of organic farmland with the increasing demand, emphasising market development and support to processors to increase the domestic production of organic food. Iceland and Norway lag behind, hampered by a restricted political will to support organic production, in spite of the threat to domestic agricultural production in general that may be posed by the rapidly increasing imports of organic food.

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CROP DIVERSITY AND PRODUCTIVITY UNDER ORGANIC FARMING IN LITHUANIA

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Abstract. *In Lithuania, the land area under organic management has been steadily increasing over the recent years. A research and development project was implemented in Lithuania with the aim of ascertaining crop strukcure, plant diversity and crops productivity in organically-managed farms under different soil conditions. In mixed farms, involved both in crop and animal production, perennial forage grasses prevailed in the crop structure, while cereals predominated in crop production farms. Crop production farms grew more grain legumes and their mixtures with cereals compared with mixed farms. Of grain legumes, field pea (semi-leafless) occupied the largest area. Lithuania's natural conditions are suitable for the cultivation of cereals, which are the main crops in the organic farm. Central Lithuania's soils are best suited for winter wheat cultivation. The total production area of spring cereals is slightly bigger than that of winter cereals. The greatest crop species diversity (on average 8 species) was recorded in the farms present in Central Lithuania, characterised by fertile soils, where conditions for both crop production and animal production are favourable. The productivity of organically - managed crops was unstable and varied within a very wide range. This was influenced not only by natural and soil conditions but also by the different agronomic practices applied.Winter cereal was slightly more productive than spring cereal.*

Key words: *organic farming, crop structure, yield, plant diversity.*

INTRODUCTION

Organic agriculture is generally perceived as an environment-safe or at least friendly farming method [1], and this is one of the reasons why the current consumption of organic products is on the increase [2]. Researchers from many countries and advocates of organic farming agree that organic agriculture has to be developed in the concept of sustainability, and its application proceeds using certain control measures pre-established and defined by international and national documents [3]. Organic farming system encompasses various aspects that are of interest both to researchers and agricultural producers. In many counties, attempts are being made to search for scenarios for the development of future sustainable agriculture by estimating the consequences of economic and environmental impacts on a farm level and by looking for means affecting production environment but facilitating mitigation or neutralization of undesirable effects [4]-[6].

Farms involved in organic production are being expanded in Lithuania. However, the larger part of organic farms have abandoned animal production (in 2012, the latter farms accounted for 35.1% of the total farms) and have been specializing in marketable crop production.

The relief of Lithuania's terrain was formed by the last glaciers that resulted in the formation of very diverse soils. According to climate and soil peculiarities, the country's territory is divided into three regions – western, central and eastern. Intensive soil erosion processes are taking place in West Lithuania's relief, where the soils are characterised by unequal texture, lower fertility as well as crop productivity, and higher production costs and where crop cultivation technologies are aimed at erosion reduction. Plains account for 95% of Central Lithuania's Lowland where the most fertile soils – *Cambisols* and *Calcaric Luvisols* prevail. East Lithuania has the highest proportion of low productivity soils. Natural and soil conditions of all Lithuania's regions are favourable for animal production (agroclimatic conditions determine the choice of the most suitable animal production branch: dairy and beef cattle production, pig production, sheep production, livestock breeding, etc.); however, due to economic and social reasons, farmers lack interest in developing these activities. As a result, commercial crop production farms prevail.

Aim of the studies was to evaluate the crop structure, plant diversity and crops productivity in organically-managed farms under different soil (region of Lithuania) conditions.

MATERIALS AND METHODS

In 2012-2013, a research and development project "Assessment of agricultural load on agrocenoses of organic farming and phytosanitary state of crops grown" was implemented jointly by the Lithuanian Research Centre for Agriculture and Forestry and Chamber of Agriculture of the Republic of Lithuania. Monitoring of organic production farms was carried out. It involved periodical and systematic survey of the selected organic farms, collection and analysis of information, and provision of forecasts. The farms for monitoring were selected having analysed the data on certified organic production obtained from the Lithuanian Institute of Agricultural Economics and Public Institution "Ekoagros". Organic farms were divided into groups according to regions – West, Central and East Lithuania; according to specialization – crop production and mixed farms; according to size: < 30 ha, 31-100 ha and > 100 ha. Monitoring was performed in three stages: i) in spring – analysis of crop structure and plant diversity; ii) before harvesting – establishment and assessment of crop productivity. During the period of monitoring, samples were taken and stands of cereals (wheat, rye, triticale, barley, oats) and grain legumes (pea) were assessed. Plant samples for the determination of biometric indicators and biological yield were collected before harvesting. Before harvesting, 8 samples were taken from each crop stand, all stems including productive ones, grain number and weight per ear, 1000 grain/seed weight were calculated. Biological productivity was calculated according to the formula (1):

$$((PD*GrE)*TGw)/1000, \qquad (1)$$

where PD – productive cereal density, unit m^{-2}; Gs – grain number per ear, unit m^{-2}; TGm – thousand grain weight, g. The productivity was recalculated into kg ha^{-1}.

RESULTS AND DISCUSSION

Crop structure and plant diversity

The size (ha) of Lithuania's organic farms is highly variable. Monitoring was performed in farms whose area ranged from 5.4 to 781.7 ha. In West and East Lithuania, farms with an area ranging from 30 to 100 ha are predominant, while in Central Lithuania those with an area of over 100 ha. Crop production farms were smaller in size compared with mixed farms. When estimating farming possibilities and quality, farm size is an important factor to consider, since unequal farming conditions form in differently sized farms and different crop cultivations are used. In West Lithuania prevailed mixed organic farms (crop and animal production), in Central and East Lithuania – crop production farms.

Farmers choose those crops for cultivation for which the climate and soil conditions are suitable and which can produce the highest yield at the lowest possible production costs and inputs. However, the choice of crops is also considerably influenced by the level of direct payments and market. The crop structure of organic farms was unstable and varied between years, especially in crop production farms. Perennial forage grasses predominated in the crop structure of mixed farms, while in crop production farms the prevalent crops were cereals and grain legumes (Table 1).

Practically no perennial grasses were grown by organic crop production farms (Table 2). Some farms grew them to sell as forage as well as seed or for soil restoration. In Central and East Lithuania's large crop production and animal production mixed farms, cereals accounted for a large portion in the crop structure (up to 58.2 and 48.6%, respectively). The highest concentration of cereals (up to 80.1%) was in the crop production farms of Central Lithuania (31-100 ha). Grain legumes occupied the largest areas there also.

Black fallow and green manure fallow account for a very small portion of arable land and are commonly used for the control of perennial weeds or for the restoration of soil fertility. As a result, fallows occupy the largest area in crop production farms where no perennial grasses are grown and there is no manure. Smaller farms (especially those specialising in crop production) are involved in horticulture, gardening and or cultivation of medicinal herbs.

Table 1

Crop structure in organic mixed crop production and animal production farms (2010-2013, averaged data)

Region	Farm size ha	Crop share in the crop structure (variation range from to), %					
		Total crops			Perennial grasses	Other plant species *	Various fallows
			Cereals	Grain legumes			
West Lithuania	<30	-**	-	-	-	-	-
	31-100	0-26.3	0-26.3	0	68.9-100	0-2.8	0-1.1
	>100	24.8-38.6	12.3-27.2	11.5-12.5	61.3-76.8	0.1-0.7	0
Central Lithuania	<30	37.7	26.2	11.5	58.6	3.8	0
	31-100	-	-	-	-	-	-
	>100	44.0-92.7	17.3-58.2	17.1-41.6	3.8-54.2	0-9.9	0-0.6
East Lithuania	<30	25.8-51.8	16.9-37.7	8.9-23.9	36.0-69.22	5.4-28.7	0-6.7
	31-100	6.4-76.2	0-48.0	0-28.2	9.9-91.0	9.0-13.9	0
	>100	34.1-74.6	19.9-48.6	14.0-26.0	24.4-64.0	0.3-2.1	0-0.7

* horticultural, garden plants, medicinal herbs, ** data not available

Table 2

Crop structure of organic crop production farms (2010-2013, averaged data)

Region	Farm size ha	Crop share in the crop structure (variation range from to), %					
		Total crops			Perennial grasses	Other plant species *	Various fallows
			Cereals	Grain legumes			
West Lithuania	<30	21.8	15.7	6.1	49.4	28.7	0.1
	31-100	69.6-100	33.5-53.0	36.0-47.0	0	0–30.4	0
	>100	50.3	27.0	16.0	0.7	56.2	0.1
Central Lithuania	<30	69.7-78.5	20.7-73.5	5.1-49.2	0-24.7	7.7-28.3	1.8-3.7
	31-100	96.4-100	62.5-80.1	19.9-33.8	0-0.5	0-3.2	0
	>100	90.1-98.1	53.5-70.2	15.4-44.6	0	1.9-14.4	0-0.1
East Lithuania	<30	78.8	63.5	10.8	10.3	12.7	4.5
	31-100	52.1-73.6	18.0-69.5	0-55.6	0	22.9-26.4	0
	>100	27.8-73.6	27.8-78.2	0-30.3	3.6-35.9	3.0-23.5	0-12.9

* horticultural, garden plants, medicinal herbs,

Crop species analysis showed that four and fewer crop species (most of which are cereals) and seven and more crop species were grown by 41.2% of the organic farms surveyed. Comparison of the data from years 2013 and 2010 indicated that the number of crops grown tended to increase, especially in larger farms. The greatest crop species diversity (on average 8 species) was recorded in the farms present in Central Lithuania, characterised by fertile soils, where conditions for both crop production and animal production are favourable. Some farmers diversified their crop structure by including maize, millet, linseed flax, oilseed rape. The greater the plant diversity, the more organic matter and more varied nutrients are accumulated in the soil, which results in a better phytosanitary state of the farm.

Productivity of crops.

Lithuania’s natural conditions are suitable for the cultivation of cereals, which are the main crops in the country. Cereal cultivation has been encouraged by increased grain exports and grain purchasing prices. East and Central Lithuania’s crop production farms grew the largest area of winter cereals (up to 49.2%), in West Lithuania the area under winter cereals was smaller. The data of the survey indicated that the largest winter wheat production areas were in Central Lithuania’s organic production farms, because Central Lithuania's soils are best suited for winter wheat cultivation [7] and because these farms are the largest. In West and East Lithuania's regions the production area of winter cereals is much smaller. They are chosen more by crop production farms than by mixed farms. On less productive soils farmers grow less demanding crops such as winter rye (in East Lithuania) and triticale (in West Lithuania).

The analysis of biological yield of the most common cereal species grown in organic farms showed that the productivity of winter cereals was unstable and varied within a very wide range (Table 3).

Table 3

The biological yield (t ha^{-1}) of most common winter cereals grown in organic farms

Region	Yield	Winter wheat		Winter triticale		Winter rye	
		2012	2013	2012	2013	2012	2013
West Lithuania	from–to	-*	-	-	2.1-4.7	-	2.9-4.3
	average	-	4.2	4.2	3.5	-	3.6
Central Lithuania	from–to	2.7-6.6	2.2-4.4	-	-	1.9-2.7	-
	average	4.2	2.3	-	4.0	2.3	4.9
East Lithuania	from–to	2.7-4.7	2.4-2.9	3.8-4.9	-	1.7-3.3	1.6-4.4
	average	3.7	2.7	4.3	2.8	2.5	2.0
Total Lithuania 2012-2013	from–to	2.2-6.6		2.1-4.9		1.6-4.4	
	average	3.4		3.7		3.1	

* data not available

This was influenced not only by natural and soil conditions but also by the different agronomic practices applied: pre-crops, fertilization and other management practices. Winter wheat was slightly more productive than winter triticale, and the latter was more productive than winter rye. The greatest grain yield variation range was established for winter wheat, which is more demanding in terms of soil and management. Wheat and rye grains in 2012 were larger (1000 grain weight – 39.5, 37.3 g, respectively) than in 2013 (35.4, 35.2 g, respectively). The differences in triticale grain size between the two years were inappreciable.

Table 4

The biological yield (t ha^{-1}) of most common spring cereals and grain legumes grown in organic farms

Region	Yield	Spring barley		Oats		Pea	
		2012	2013	2012	2013	2012	2013
West Lithuania	from-to	1.1-2.9	2.8-3.3	1.2-1.7	3.3-5.0	-	-
	average	1.8	3.0	1.5	4.1	-	2.0
Central Lithuania	from -to	2.4-3.6	-*	1.6-4.6	-	1.3-5.4	-
	average	3.2	2.4	2.9	4.0	3.6	3.5
East Lithuania	from -to	1.2-2.7	-	-	1.5-1.8	2.2-4.2	1.5-4.1
	average	2.1	3.7	-	1.7	3.2	2.8
Total Lithuania 2012-2013	from -to	1.1-3.6		1.2-5.0		1.3-5.4	
	average	2.7		2.8		3.0	

* data not available

The total production area of spring cereals is slightly bigger than that of winter cereals. In crop production farms, especially in those of Central Lithuania, they account for nearly half of the total crop structure. With increasing farm area, more spring cereals are grown in mixed farms. Barley, which has been a dominant spring cereal crop in crop production farms for a long time, is being replaced by wheat, triticale and other spring cereals. The largest areas of barley or its mixtures with grain legumes were cultivated in mixed farms. So far, oats have been grown on least productive soils (in West and East Lithuania). However, due to their phytosanitary and agronomic properties and grain demand in the market of organic products, oats production area has increased. Currently oats are grown all over Lithuania, especially in crop production farms. In West Lithuania, because of adverse wintering or poor autumn conditions, farmers tend to choose spring cereals instead of winter cereals. The average productivity of spring cereals (spring barley, oats) was 2.8 t ha^{-1} or 17.6 % lower than that of winter cereals (Table 5).

Spring cereals were most often grown after winter cereals and got into the worst place in the crop rotation. The situation has been changing recently. Our data showed that spring barley was mostly grown by mixed farms, which grew perennial grasses and applied farmyard manure to restore soil fertility, therefore spring barley productivity was relatively stable. Crop production farms grew other spring cereals, characterised by a good weed suppressive ability and greater demand on the market.

Oats were grown all over Lithuania on various soils using different management practices. Oat yield varied from 1.2 to 5.0 t ha^{-1}. However, on less fertile soils the yield of properly cultivated oats was similar to that of other cereals. Barley grains were large (1000 grain weight – 41.1 g), oat grains were small (1000 grain weight – 31.7 g).

Legume plants are valued because they enrich the soil with symbiotically fixed atmospheric nitrogen and are a source of nitrogen in the crop rotation. Crop production farms grew more grain legumes and their mixtures with cereals compared with mixed farms. The largest area cultivated with these crops was in Central and East Lithuania's farms. Of grain legumes, semi-leafless pea occupied the largest area. Some farmers chose other grain legumes: beans, soy, lupine and vetch. Mixed farms (crop and animal production) cultivated mainly legume/cereal mixtures. However, few farmers pay attention to effective use of nitrogen accumulated by legumes. Pinder et al. (2012) suggest that nitrogen from legumes when their biomass is used as green manure can have negative effects on soil and water quality and climate change (due to N_2O, NH_3 losses) [8]. Development and introduction of innovative elements and technologies in organic crop production farms can serve as an alternative for organic animal production [9].

Biological grain yield of semi-leafless pea was unstable and ranged from 1.3 to 5.4 t ha^{-1}. There is a greater likelihood to produce higher and more stable pea yields in Central Lithuania and regions close to it. In the survey, the farmers indicated the reasons for such low pea grain yield: high weed infestation, disease and pest incidence, losses during harvesting, yield handling and storage. Most of the farmers grew peas according to conventional technology but without the use of synthetic fertilizers and pesticides. Unlike in conventional agriculture much attention has to be devoted to weed control, i.e. choice of pre-crops, mechanical weed control, alternative pea cultivation methods (intercrops, wide inter-row spacing and others).

Crop yield reduction in organic farming depended on plant species and the soil conditions (region) (Figure 1).

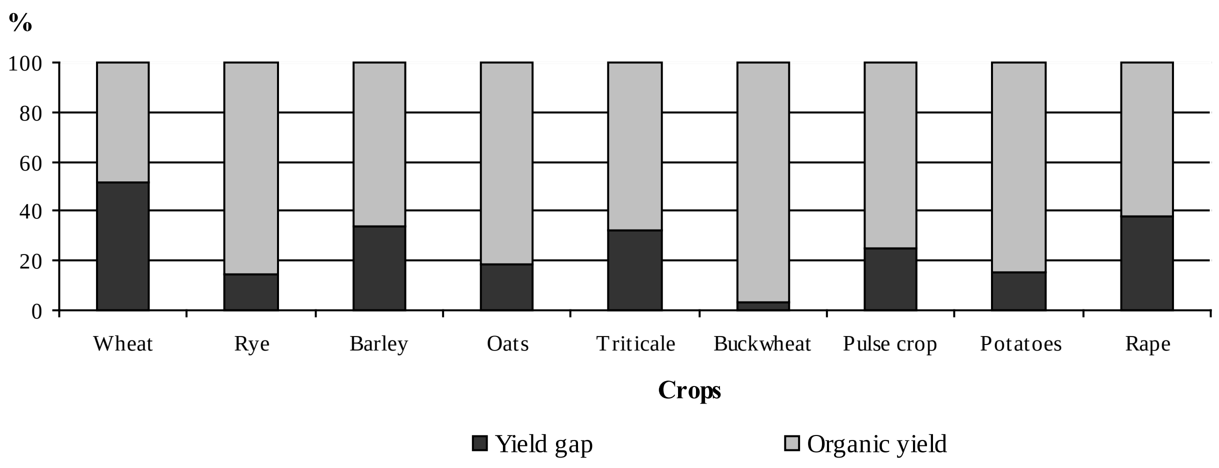

Figure 1. **Crop yield gap (%) between organic and conventional agriculture in Lithuania (2010-2013)**

Organically-managed winter wheat, triticale, spring barley, oilseed rape reduced grain/seed productivity by 51.4%, 32.0%, 34.2% and 38.0% respectively, compared with managed in intensive agriculture. Buckweat was less sensitive to the organic management.

CONCLUSIONS

1. When choosing production specialization, farmers often disregard regional differences, which are largely determined by soil and climate. The crop structure of organic farms was unstable and varied between years, especially in crop production farms. Perennial forage grasses predominated in the crop structure of mixed farms, while in crop production farms the prevalent crops were cereals and grain legumes. The highest concentration of cereals (up to 80.1%) was in the crop production farms of Central Lithuania (31-100 ha).

2. The greatest crop species diversity (on average 8 species) was recorded in the farms present in Central Lithuania, characterised by fertile soils, where conditions for both crop production and animal production are favourable.

3. The grain yield of organically grown winter wheat, triticale and rye was 3.4, 3.8 and 3.1 t ha^{-1}, respectively. The grain yield of spring barley and oats was lower and amounted to 2.7 and 2.8 t ha^{-1}. The yields of organically grown crops were optimal but unstable.

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IN ORGANIC CROP ROTATION WINTER COVER CROPS IMPROVE SOIL, WEED SUPPRESSION AND CROP YIELDS

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Abstract. *The aim of this study was to investigate the effects of different winter cover crops (CC) in combination with composted cattle manure on weed infestation, crop yields and soil characteristics. The experiment was conducted in 2012-2014 in three different organic cropping systems under five-field crop rotation (barley undersown with red clover, red clover, winter wheat, peas and potato). The control system followed the given rotation, whilst in the second and third organic system also winter cover crops (ryegrass after winter wheat (in 2012) and mixture of winter oilseed-rape and winter rye (since 2013); winter oilseed rape after pea and winter rye after potato) were used. In the third organic system composted cattle manure in addition to winter cover crops was applied. The results indicate, that winter cover crops reduced the dry biomass and density of weeds compared to the control system. In 2012 and 2013 the best suppressor of weeds was winter rye, in 2014 the mixture of winter rye and oilseed rape. In 2012 and 2013 there was a statistically significant increase of barley and potato yields under the combination of green manure with cattle manure. These results also indicate a remarkable improvement of soil properties, such as the decrease of soil acidity and increase of Carbon (C) content.*

Key words: *winter cover crop, weeds, carbon, soil pH, crop yield.*

INTRODUCTION

The first and capital principle of agronomy and thus the key for successful crop production begins with proper soil management by growing technologies [1]. However, in organic farming weeds are the main crop yield decreasing factors. In ecologically friendly cultivation weeds can be controlled by crop rotation, harrowing, inter-row tilling, mulching, growing legumes in rotation and cover crops [2],[3].

Winter cover crops drilled after the main crop harvest prevent nutrient leaching and improve other soil characteristics [4],[5] when incorporated into the soil [5].

Cover crops can improve agro-ecosystems in many ways: they provide soil cover and thus prevent water and wind erosion [6],[7], absorb, convert and redistribute nutrients, increase the soil organic matter content [8], ensure habitats for beneficial insects and suppress weeds by providing competition for water, light, nutrients and space or by releasing allelopathic chemicals from either living or decomposing plant tissue [9],[10]. Cover crops also avoid or reduce the soil-borne plant diseases [11]. In Estonian conditions the study of role of winter cover crops in crop rotation was started only few years ago. The aim of the study is to investigate the influence of different winter cover crops and their combination with composted cattle manure on soil properties (soil organic carbon content and pH), weeds and crop yields in three organic farming systems.

MATERIALS AND METHODS

Experimental site and design:

The five-field crop experiment with three different organic systems was started in 2008. The crops grown in succession were as follows: barley (*Hordeum vulgare L.*) undersown with red clover (*Trifolium pratense L.*), red clover, winter wheat (*Triticum aestivum L.*), peas (*Pisum sativum L.*), and potato (*Solanum tuberosum L.*). The control System (Org 0) followed this rotation. Winter cover crops were used as green manure in System Org I: ryegrass in 2012 and the mixture of oilseed rape and winter rye in 2013 after winter wheat, winter oilseed rape after peas and winter rye after potato. In System Org II winter cover crops were used as green manure and in spring composted cattle manure – 20 t ha^{-1} for potato, 10 t ha^{-1} for winter wheat and for barley was applied.

The experiment itself was established in four replications, each plot (60 m^2) situated in a systematic block design. The field is the property of the Department of Field Crop and Grassland Husbandry of the Estonian University of Life Sciences. The field's location is near Tartu (58°23´N, 26°44´E). The soil type was sandy loam Stagnic Luvisol according to the World Reference Base classification [12], the humus layer was 20-30 cm [13]. The ploughtable layer was 27-29 cm.

The cover crops were sown with the Kongskilde sowing machine right after the harvesting of the main crop and in the beginning of May they were ploughed into the soil. In cereals, potato and peas mechanical weed harrowing was used to control weeds. Red clover was cut twice: mid of June and during the second half of July and ploughed into the soil in all organic systems. Cereals and peas were harvested at the beginning of August, using a Sampo Rosenlew experimental harvester. Potato tubers were hand-collected in August-September. Yield data were adjusted to dry matter content.

Soil samples

Soil samples were collected once a year in April before any field operation, by taking eight samples per plot from 0 to 25 cm depth for making one average sample. Every sample was air-dried, ground and passed through a 2 mm sieve. An aqueous solution of soil was prepared in KCl 1M (1:2.5) for determining the pH, meanwhile the organic carbon concentration (Corg) was determined by the Tjurin method.

Weed samples

All data regarding the five-field crop experiment was collected according to TILMAN-ORG Handbook of Methods [14]. Total dry mass and density of weed species were measured in the end of April before the cover crops were ploughed into the soil and three weeks before harvesting the rotational crops. All measurements were carried out in four replications per each plot with a 25 x 25 cm frame. All weed specimens were collected and counted by species. Total biomass was weighted using only aboveground biomass after the weed samples were dried (80 °C) to a constant weight.

Weather conditions

The experimental field is situated 59 m above sea level and is a part of the South-Estonian upland agro-climatic region. The average annual sum of active air temperatures (daily average>5 °C) is 1750-1800 °C, mean annual temperature + 4.4 (+30…-30) °C with precipitation rates of 550-650 mm. The weather conditions in 2012 and in 2013 differed significantly – in 2012 the total precipitation during the growth period was 102 mm higher than usual, whereas in 2013 the summer was mostly hot and dry, compared to the long-term average values. In 2014 the spring was warm, but the beginning of summer was rainy and cold whereas in July the weather turned warm again.

Data analyses

Statistical analyses were performed by using the Statistica software package (version 11.0). Significant differences between cropping systems, winter cover crops and experimental year were tested by Fisher's least significant difference test. The statistical significance level was set at $p<0.05$.

RESULTS AND DISCUSSION

Soil carbon content and pH

Planting cover crops before the main crops can significantly improve physical, chemical and biological characteristics of the soil, thus leading to much improved soil health and thereby higher yield of the principal crops. The increase of C content provides more stable soil structure and this increases aeration, soil water holding and buffering capacities. Furthermore, sufficient organic matter content in the soil allows the release of available nutrients to plants [5],[16],[17]. Both winter cover crops (Org I) and winter cover crops with cattle manure (Org II) had tendencies to the accumulation of organic C with time (Fig 1) and thus reduced the acidity of the soil. The excessive soil acidity inhibits the availability of plant nutrients and thus the growth and development of plants is supressed, but with the decrease in acidity the nutrient availability recovers [16]. Compared to Control System (Org 0), there was a significant rise in soil pH in Systems Org I and II (Fig 2). The decrease of soil acidity in Systems Org I and II is mostly due to the increase of C content in the soil. The increase of C content and decrease of acidity indicates also, that cover crops improve soil physical, chemical, and biological properties, thus improving the productivity of subsequent crops [5], [16].

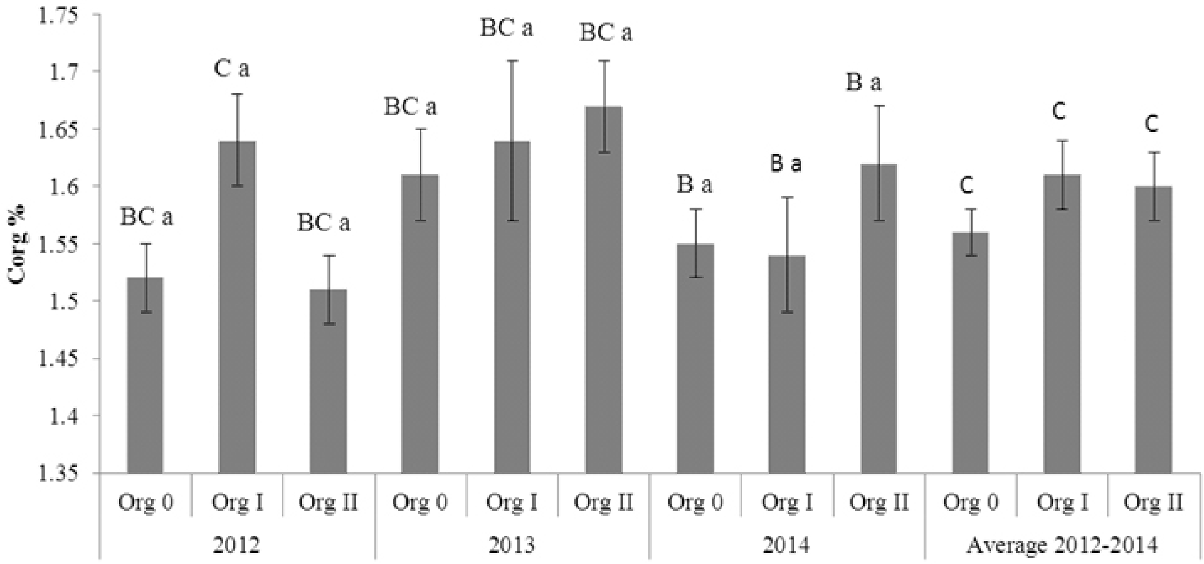

Figure 1. **Total C content (%) in the soil in spring in organic cropping systems in 2012-2014. (Org 0 – without CC, Org I – with CC; Org II – with CC and composted cattle manure). Means followed by a different capital letters indicate significant influence (Fisher's LSD; $p < 0.05$) of the system, small letters indicate significant influence ($P < 0.05$) of the year. ± value represents standard error of the mean (SE).**

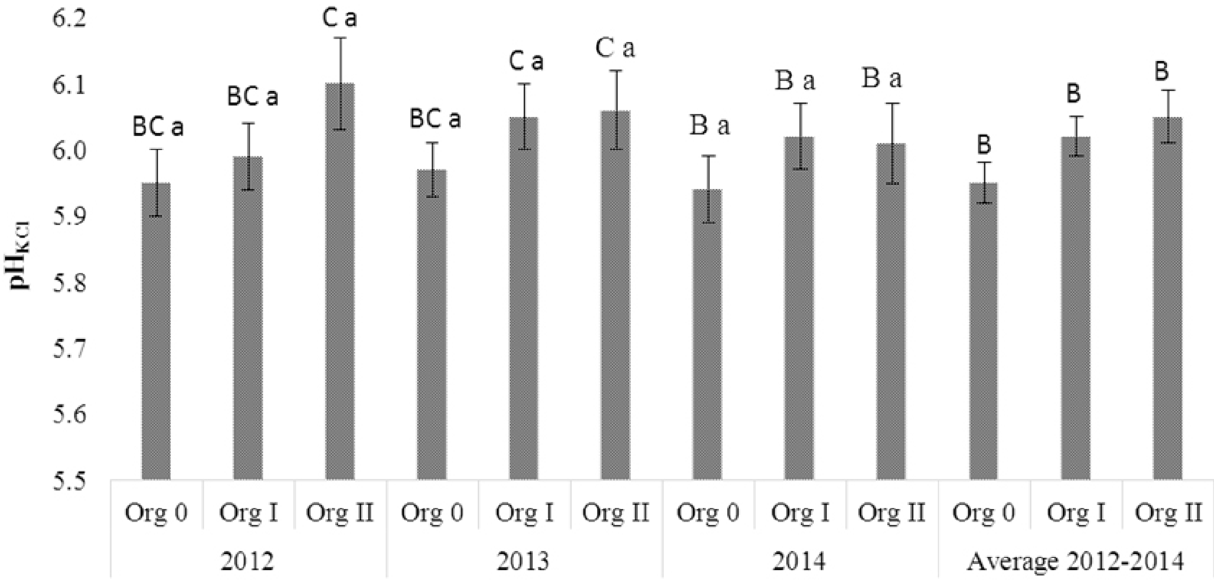

Figure 2. **Soil pH in spring in organic cropping systems in 2012-2014. (Org 0 – without CC, Org I – with CC; Org II – with CC and composted cattle manure). Means followed by a different capital letters indicate significant influence (Fisher's LSD; $p < 0.05$) of the system, small letters indicate significant influence ($P < 0.05$) of the year. ± value represents standard error of the mean (SE).**

Weed infestation before cover crop incorporation

Since cover crops control weeds in arable fields under organic farming conditions, the biomass and density of the weeds were influenced by the system, the cover crop species and the year. In 2012 the weed dry biomass was the highest in winter oilseed rape and lowest in winter rye (Fig 3). The weed density was also the lowest in winter rye (Fig 4). In autumn of 2012 mixture of winter rye and oilseed rape as green manure cover crop was used instead of ryegrass. Such replacement was made due to very small amount of ryegrass biomass, which did not supress weeds efficiently. This phenomena is significantly demonstrated by

measurements of weed density, which was highest in ryegrass (Fig 4). This finding is also confirmed by earlier research made regarding the ryegrass biomass production in Estonian conditions [15].
In 2013 the weed biomass was similar to previous year – the highest in winter oilseed rape and lowest in winter rye, with statistically significant results in System Org II (Fig 3). The weed density results were in accordance with the weed biomass with highest rate in winter oilseed rape and lowest in winter rye with also statistically significant results in System Org II (Fig 4). In 2014 the results somewhat differed from previous years – weed biomass was the highest in winter rye (Org I). The lowest biomass values were observed in the mixture of winter rye and oilseed rape (Fig 3). Weed density on the other hand was highest in winter oilseed rape and the lowest in the mixture of winter rye and oilseed rape (Fig 4), similarly to the biomass values.

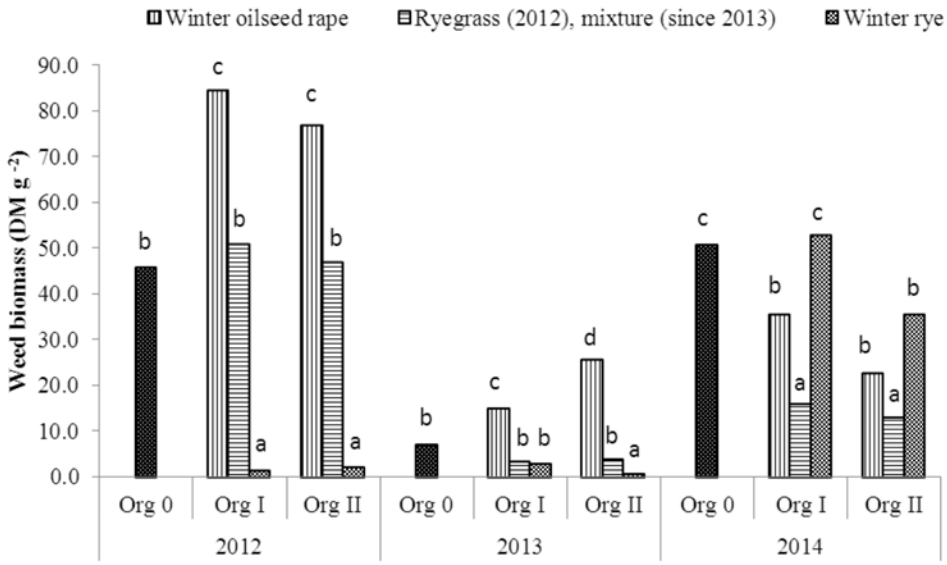

Figure 3. **Weed dry biomass (g m^{-2}) in green manures as winter cover crops (CC) before incorporation to soil in organic cropping systems in 2012-2014. (Org 0 – without CC, Org I – with CC; Org II – with CC and composted cattle manure). Different letters indicate significant influence ($p < 0.05$) of cropping systems in different years.**

These results indicate, that winter rye has very good weed suppressing ability compared to other winter cover crops. Furthermore, besides the lower biomass values in winter rye, the weed density was also lower than in other crops. As an exception 2014 could be pointed out, where weed biomass was highest in winter rye (Fig 3). This could be resulted from poor tilling of the rye in autumn.

Crop yields

Green manures had tendencies to increase yields in all rotation crops. Statistically significant increase of barley yield was reached in 2012 and 2013 in System Org II, but in 2014 no significant differences were found (Fig 5). As the 3year average, the yield significantly increased in Org II. A possible explanation for the yield increase may be associated with the effect of manure and cover crops. While in 2012 the yield of winter wheat increased significantly in System Org II, in 2013 and 2014 the tendency was stronger due to the effect of cover crops in Org I system. The lower yield level in last two years was caused by unfavourable weather conditions.
The yield of potato varied significantly between experimental years. In 2013 with drought conditions the effect of enhanced soil conditions on potato yield was observed, when potato yield increase significantly under systems Org I and Org II. The results also indicated that in organic rotations with winter cover crops high yield of peas for organic cultivation are achievable (depending on year and cropping system 1.6-2.9 DM t ha^{-1}) (Fig 5).
Our findings are consistent with those pointed out in [5], where there is claimed, that soil organic matter content contributes positively to soil fertility, crop yields and overall soil sustainability, which all are achievable by growing cover crops as green manure.

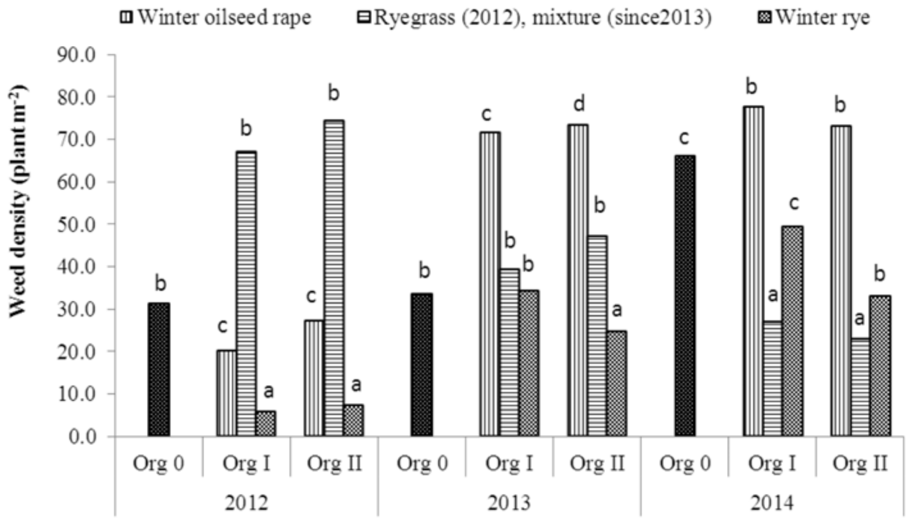

Figure 4. **Weed density (plant m^{-2}) in green manures as winter cover crops (CC) before incorporation to soil in organic cropping systems in 2012-2014. (Org 0 – without CC, Org I – with CC; Org II – with CC and composted cattle manure). Different letters indicate significant influence ($p < 0.05$) of cropping systems in different years.**

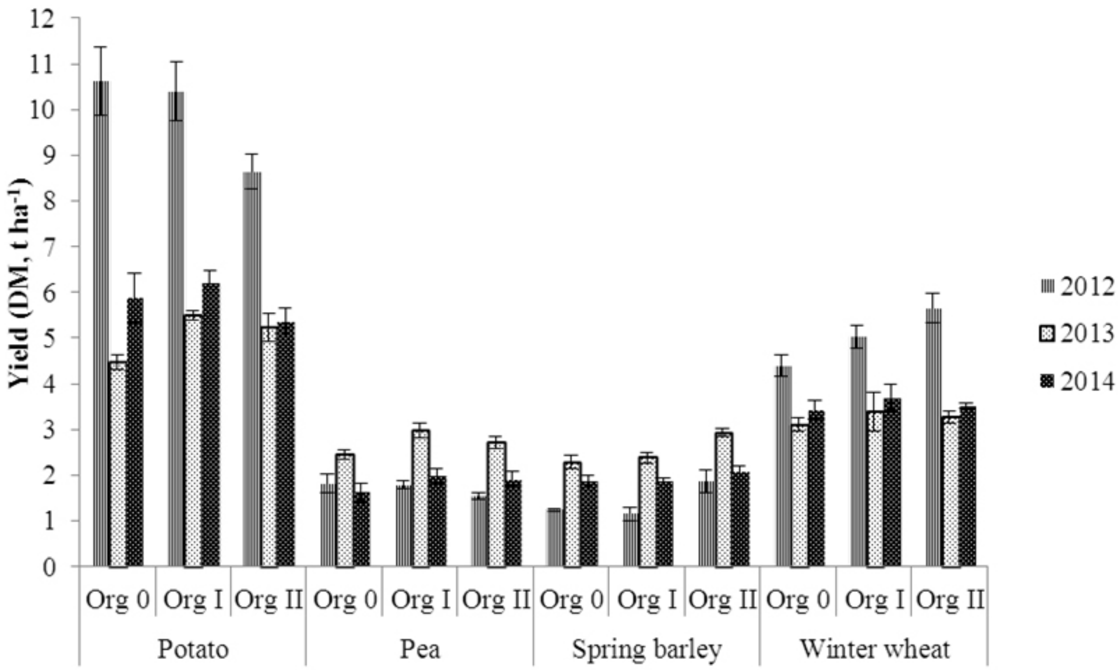

Figure 5. **Yield of rotation crops (DM, t ha^{-1}) in 2012-2014. (Org 0 – without CC, Org I – with CC; Org II – with CC and composted cattle manure). ± value represents standard error of the mean (SE).**

CONCLUSIONS

By addition of winter cover crops to the rotation, soil organic matter content can be increased, with or without manure application (systems Org I and Org II). Also the increase in soil fertility (C content) ensures the decrease in soil acidity in Org I and Org II systems. This study has shown that by growing winter cover crops as green manure weed infestation is reduced. Significant importance is on the species of the cover crop: as an average of experimental years the weediness before ploughing the cover crops into the soil was the lowest in variants where winter rye was used. As a result of improved soil fertility the yield of crops in the rotation has been increased. By incorporating the winter cover crops into crop rotation better conditions for higher yield and sustainable cultivation are established.

ACKNOWLEDGEMENTS

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ANAEROBIC DIGESTION OF ANIMAL MANURE – IMPLICATIONS FOR CROP YIELDS AND SOIL BIOTA IN ORGANIC FARMING

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Abstract. *Anaerobic digestion of farmyard manures may help farmers to produce bioenergy instead of using fossil fuels, support cycling of nutrients and reduce greenhouse gas emission. However, compared to pristine slurry, digested slurry has a reduced content of organic carbon which may impact the soil biota negatively due to substrate shortage. Our knowledge on these processes and their influence on soil quality is scarce. Hence, a field experiment with two organic cropping systems (grass-clover ley and arable system; at two slurry-application levels) was established in 2011, to study how application of digestates affects crop yields, soil characteristics and soil biota (earthworms, springtails, microbiota). The grass-clover system showed comparable yield levels over 3 years when digested slurry was compared to untreated slurry. Digested slurries had no influence on soil nutrient concentrations or on soil organic matter levels over the first 2 years. Application of high levels of manure increased the mortality of both surface-dwelling and soil-living earthworms just after application, but the long-term effect of manure application seemed more positive, especially at low application levels. Springtails and microorganisms seemed only little affected by application of digested slurry.*

Key words: *Collembola, bioenergy, grass-clover, digestate.*

INTRODUCTION

Agriculture is criticized for emitting high amounts of greenhouse gas, both as methane (CH_4) and nitrous oxide (N_2O), through the use of fossil energy and animal husbandry. By anaerobic digestion (AD) of farmyard manures, farmers may produce biogas to replace fossil fuels and reduce the emission of methane produced during storage of slurries. AD may also ease the handling of the manure and reduce viability of animal pathogens and weed seeds [1]. However, the process needs stable temperatures of at least 30°C, so the construction and maintenance of small-scale biogas plants for Nordic conditions requires technically skilled farmers. AD alters the physicochemical composition of the manure, reducing the proportion of easily degradable C in the digested manure. This may negatively affect soil organic matter pools and the soil biota that live on the organic C. Organic nitrogen (N) is mineralised during AD, thus enhancing the proportion of mineral N in the digestate compared with untreated manure [2]. The higher concentration of ammonium, constituting most of the mineral N, may be toxic to soil fauna, such as earthworms [3]. On the other hand, when used as fertilizer, greater availability of N applied in the digestate may increase root and shoot residues due to increased plant growth. This may compensate for the organic C lost during digestion, and support the growth of soil fauna and microorganisms. The effects of AD on the quality of animal manure, and derived effects on crop yields and biota, are studied in the project “SoilEffects” at Tingvoll, NW Norway. Results from 2011-2014 are presented, to evaluate whether AD affects manure, crop yields and quality or soil fauna and microbiota.

MATERIALS AND METHODS

Anaerobic digestion of manure

A biogas plant was established in 2010 at Tingvoll Research Farm, owned by the Norwegian Centre for Ecological Agriculture, to treat the slurry from 25 organically managed dairy cows. In spring 2011, an associated field experiment was initiated to study long-term effects of AD treated slurry on soil quality characteristics and crop yields [4]. Because a stable digestion process was first reached in autumn 2011, both the conventional dairy cow slurry and digestate applied in 2011 was obtained from Bioforsk, Soil and Environment Division (Ås), where the digestate was produced in a 6-m^3 batch digester. In later seasons, digested and non-digested slurries were sampled during winter and stored in 1-m^3 plastic containers at Tingvoll. The farm has a loose-housing cow house, from which slurries flow to a collection pit. Until a pump was installed to homogenize the slurry during flow, only the most liquid part of the slurry went into the digester. Hence, during 2012-13, the physicochemical differences between digested and non-digested slurry were less than those normally found in such comparisons. When better homogenisation was achieved, the content of dry matter (DM) and the proportion of mineral N became closer to those obtained in other AD studies [2] (Table 1).

Field experiment and treatments

Non-digested and digested slurry were applied at two levels in two cropping systems: 1) arable crops (without legumes) with annual ploughing and 2) perennial grass-clover ley (established in 2009). The crops in the arable system were oats in 2011, annual ryegrass in 2012 and spring wheat (harvested, before complete ripeness) in 2013. In 2014, the whole field was ploughed and a new grass-clover ley was established, with green fodder (oats, peas and vetches) as a cover crop. Low (L) and high (H) application levels of digestate (DL, DH) and non-digested slurry (NDL, NDH) contained total N levels of 85 and 170 kg ha^{-1} yr^{-1} , respectively, to arable crops, and 110 (L) and 220 (H) kg ha^{-1} to the perennial ley. This comprised about 25 and 50 tonnes ha^{-1} of slurry in low and high treatments in the arable system (one application), and 20 + 10 and 40 + 20 tonnes ha^{-1} (in early spring + after 1st cut) in the grass system. A control treatment with no slurry was included in both cropping systems. Addition of water to the control was considered unnecessary, due to the high precipitation rates at the Tingvoll area (average of 126 mm per month, April-September, 1995-2014). Each cropping system had four replicate blocks. Within each block, the five treatments (control, NDL, NDH, DL, DH) were randomly distributed on experimental plots sized 3×8 m. The slurry was diluted with water to < 5% DM and applied by hand, using 10-liter cans. In arable crops, the manure was applied after ploughing and harrowing, and raked into the soil in 2011 and 2012. In 2013, the manure was applied on arable plots without ploughing, and incorporated with a horizontal rotavator. In 2014, no manure was applied, and the after-effect of 3 seasons of manure application on crop yields was recorded. The experimental soil is a loamy sand, with low status of ammonium acetate-lactate (AL) extractable phosphorus (P) (< 4 mg 100 g^{-1} dry soil) and very high status (>120 mg 100 g^{-1} dry soil) of nitric acid soluble potassium (K) (Table 2).

Measurements and statistical analyses

For measurement of the chemical composition of the slurries, representative samples were analysed for contents of ash, DM and for total concentrations of N, P, K, Mg, Ca, S and ammonium-N. In Table 1, the proportion of mineral N (NH_4-N/tot-N×100) is shown. Cold (22ºC) and hot (80ºC) water-extractable organic C [5] in manures and soil were measured using a sequential procedure. For measurements of soil pH (H_2O) and nutrient concentrations (P-AL, K-AL, Mg-AL, Ca-AL and K-HNO_3), bulked samples of 10 augerings (diameter 2 cm, 0-20 cm depth) per experimental plot were taken in spring 2011 before the start of the experiment, and in spring 2013 before manure application. The precise location of each soil augering was recorded. P-AL values in six of the 20 soil samples in the arable system were below the detection limit (< 2 mg 100 g^{-1}) in 2011. These were set to 1.5 mg 100 g^{-1} to allow for statistical analysis.

Earthworms and springtails (*Collembola*) were sampled from the grass system to study the effect of manure application over a short and an extended time span. For measurements of diversity and density, 8-liter soil cubes were sampled for earthworms and 100 cm^3 cylinders (0-3.8 cm depth) were used for springtails. Earthworms were sampled on April 13th 2011, May 4th 2012, May 8th 2013 and September 25th 2013, and sorted out by hand [4]. Springtails were sampled on April 28th 2011, and April 26th, May 3rd and June 14th in 2012 and extracted using a drying procedure [9]. The acute toxic effect of manure application on earthworms was studied in spring 2013, by recording dead earthworms on the soil surface in 1×1 m frames just after manure application. One count was made per experimental plot, with the frame placed in a fixed position in all plots. Soil microbial diversity and activity were measured in both crop systems shortly after application of slurries, by phospholipid fatty acid (PLFA) profiling (in 2011 and 2013) and soil respiration (in 2011) [4] .

For measurement of crop yields, subplots sized 1.2×7 m were harvested on the ley plots, the fresh weights were recorded and samples for botanical composition and DM content were collected. In arable plots, the same method was used for ryegrass and wheat. For oats, sheaves were made, their fresh weights recorded, and then they were dried and threshed to measure the amount of straw and grains. Statistical analyses were performed using Minitab 16 and SAS Statistical Software. A general linear model was used to test the effect of treatments on yield levels, and Tukey t-test at the 5% level to compare the mean values of treatments. For comparisons of soil analyses in 2011 and 2013, paired t-tests were used. For the PLFA data, the relative abundance (molar %) of the individual fatty acids was calculated, log transformed and submitted to principal component analysis using Unscrambler 7.6.

RESULTS AND DISCUSSION

Manure chemistry

AD led to a slight reduction in DM content, a small increase in the proportion of mineral N and an increase in pH by up to 0.5 units (Table 1). The content of cold and hot water-extractable organic C (CWC, HWC) was comparable in both ND and D. There was a tendency that digested slurry had less total WC, especially in slurry with low DM content (2012 and 2013 samples). During manure handling and application, it was frequently noticed that digested manure flowed more easily (due to its lower viscosity) and infiltrated more rapidly into the soil than did non-digested manure. The digested manure had less odour, but it had a stronger tendency to foam. Its colour was less brown, and more greenish than that of the undigested manure.

Table 1

Chemical composition of digested (D) and non-digested (ND) slurry; average values with min-max values for DM. x = missing value. CWC, HWC = cold and hot water-extractable organic C, D/ND (%) = (CWC+HWC in D)/(CWC+HWC in ND)×100.

Year, slurry type, (no. of samples)	DM %	pH	Total-N kg Mg^{-1}	Nmin % of tot-N	P	K	Mg	Ca	S	Ash %	CWC | HWC kg Mg^{-1} %D/ND
					------------- kg Mg^{-1} ------------						
2011, ND (6)	6.5 5.1-8.4	7.6	2.7	63	0.50	3.1	0.45	0.83	x	x	3.6 | 2.6
2011, D (4)	4.6 2.6-6.4	8.1	2.8	71	0.46	3.1	0.40	0.67	x	x	2.1 | 3.8 94
2012, ND (5)	3.9 3.0-5.2	7.8	2.2	61	0.39	2.5	0.36	0.83	x	x	1.7 | 2.1
2012, D (6)	2.7 1.5-4.5	7.9	1.6	59	0.33	1.6	0.29	0.64	x	x	0.9 | 0.8 45
2013, ND (3)	4.8 4.0-5.8	7.3	2.4	60	0.43	2.8	0.39	0.92	0.24	1.0	2.2 | 2.2
2013, D (4)	3.1 1.9-4.2	7.5	2.1	67	0.33	2.6	0.31	0.80	0.17	0.8	1.1 | 1.1 49
2014, ND (3)	5.4 5.2-5.9	7.5	2.6	61	0.55	3.5	0.45	1.1	0.27	1.2	3.5 | 3.8
2014, D (3)	5.0 4.5-5.3	8.0	3.1	69	0.53	3.3	0.43	1.1	0.24	1.1	2.2 | 2.5 64

Yields

In the grass system, the yield levels were increased greatly by manure application (Fig. 1), with no difference between the effect of digested manure and untreated manure. Over time, the yields declined in the control treatment, while in the other treatments they increased slightly until 2014, when the lack of manure application resulted in a marked yield decline in all treatments (Fig. 1). Although differences between yield levels in the four manure treatments were only found in some cases, there were significant differences in botanical composition between treatments with digested and undigested slurries. Grass species increased, at the expense of clover and weeds, with increasing levels of manure. Digested manure reduced the clover content to a greater extent than did the non-digested slurry (data not shown).

In the arable system, the apparent yield increment caused by manuring was not statistically significant in any year, although a tendency to enhancement ($P = 0.095$) was observed in 2013 on most of the manured plots (Fig. 2). The lack of yield enhancement was surprising, as other growth characteristics appeared to respond positively to manuring. Clear differences in straw length (significant) and plant colour were visible during the growing season of 2011 (data not shown). Yield levels in 2012 were generally very low due to poor establishment of fodder rape, which had to be replaced by a late-sown ryegrass crop.

In 2013, a horizontal rotary harrow was used for combined tillage and incorporation of manure, and the yield effects were then larger than before. Furthermore, the yield effect of digested manure was clearly better than that of undigested manure in this year. Comparisons of the mean spring wheat yield of both digested manure treatments with the mean of the untreated manure treatments and the control, showed close to significant differences (P = 0.056), with respective mean yields of 3.9(a), 3.5(ab) and 3.0(b) tonnes DM ha^{-1}. A yield increase in spring cereals with rapid slurry incorporation was found in a German study [6], in which no significant yield differences between digested and non-digested slurry were otherwise found. In 2014, the green fodder yield levels in the arable system were comparable to wheat yields obtained in 2013, and slightly lower than those achieved in the grass system in 2014.

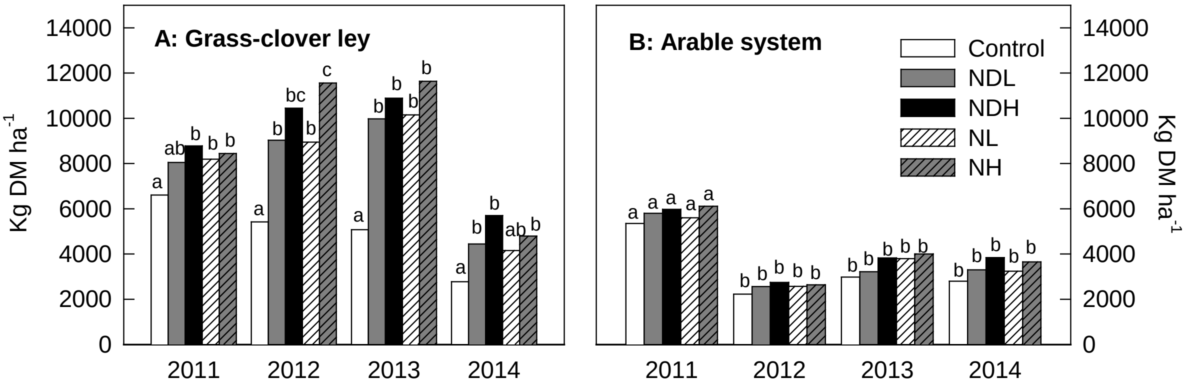

Figure 1. **Crop yields in (A) grass-clover ley and in (B) an arable system, either without manure (Control), or with low (L) and high (H) applications of digested (D) and non-digested (ND) slurries during 2011-2013. In 2014, after-effects with no further manuring were measured in green fodder in both systems.**

Soil chemistry

Some changes in soil chemistry were found, e.g. P-AL increased in most manured treatments and soil organic C was reduced in treatments with annual soil tillage [7]. This shows that the sampling technique was accurate enough to reveal possible effects caused by manure composition on relevant soil characteristics. A time span of two years is probably too short to reveal possible effects due to differences in manure chemistry caused by anaerobic digestion.

Soil fauna

Five earthworm species were found in the entire experiment and these were studied in detail in the grass system. The species *Aporrectodea caliginosa* was most common, but *Octolasion cyaneum* and *Lumbricus terrestris* were also found. In general, the density of earthworms was stable, at about 150 individuals m^{-2} in the control treatment (spring 2011 to autumn 2013). In early spring 2013 there was an exception, with densities down to 50 m^{-2}. In the manured treatments DL, DH and NDL, the mean values were slightly higher in 2013 than in 2011, in both spring and autumn. The values were about 150 individuals m^{-2} in spring, and 180-240 in autumn. With high application levels of NDH, the earthworm density declined to about 90 in spring and 120 in autumn. Hence, modest levels of manure application, independent of type, seem to increase earthworm density over a time span of one or more growing seasons. Following application of slurry in 2013, an average of 19 dead worms m^{-2} on the surface was found in the NDH treatment, and 11 in DH. In the low manure application treatments, the corresponding values for NDL and DL were 4 and 2 dead worms m^{-2}. Accordingly, at high levels, non-digested manure seemed to affect earthworms more negatively than digested manure; this was opposite to our expectations, based on their relative ammonium concentrations.

Springtails constitute a diverse fauna group which is not well described in Norwegian agricultural soils. Across treatments, 8000-40000 individuals m^{-2} were recorded on the four sampling dates [9]. We found 42 species in the experimental field [8], with one species, *Onychiurus edinensis*, not previously observed in Norway and one species, *Oligaphorura ursi*, rarely found in agricultural soil. The most common species was *Parisotoma notabilis*, followed by three species of *Mesaphorura*, two species of *Protaphorura* and *Isotomurus graminis*. A high number of *P. notabilis* has also been found in pastures in Iceland, forest habitats in Norway, and in agricultural soil in Denmark and Sweden [8].

Collembolan species may be grouped into "epigeic" (in soil surface) and "endogeic" (below soil surface), on basis of presence or absence of eye organs and colour intensity. Following this approach, we found that the epigeic species may be more vulnerable to manure application than the endogeic species (data not shown). A significant drop in springtail density was seen some days after manure application.

Soil microbial community and activity

We assumed that addition of the various slurries would have a direct effect on the diversity and activity of the soil microbial community, by supplementing the soil native C pool with readily available organic C, depending on the level and type of slurry. This could not be confirmed by analysis of hot- and cold-water extractable C (CWC, HWC) in the soil in 2011 (data not shown) where availability of C could not be correlated with slurry applications. Measurements of accumulated soil respiration supported this assumption, showing increased levels (10-15%) in treatments with high addition levels of slurry (Fig. 2A). The measurements of available C in soil also revealed that the grass-clover ley contained relatively more native available C than the soil in the arable system. This difference in soil C was not reflected in the microbial biomass, as indicated by soil total PLFA content, which was unaffected by treatments (data not shown). On the other hand, the microbial community composition was strongly influenced by the experimental conditions, as revealed in a principal component analysis of the PLFA profiles (Fig. 2B). The most marked separation/grouping of data points is along the PC1 axis (grass-clover to the left and arable system to the right) showing that the main explanation for differences in community structure was caused by the two cropping systems. Besides the cropping system, field variation in native soil characteristics may also have contributed, as the grass system had higher levels of soil organic matter. The average content of the total organic matter in the arable system was 6%, and in the grass system 11%.

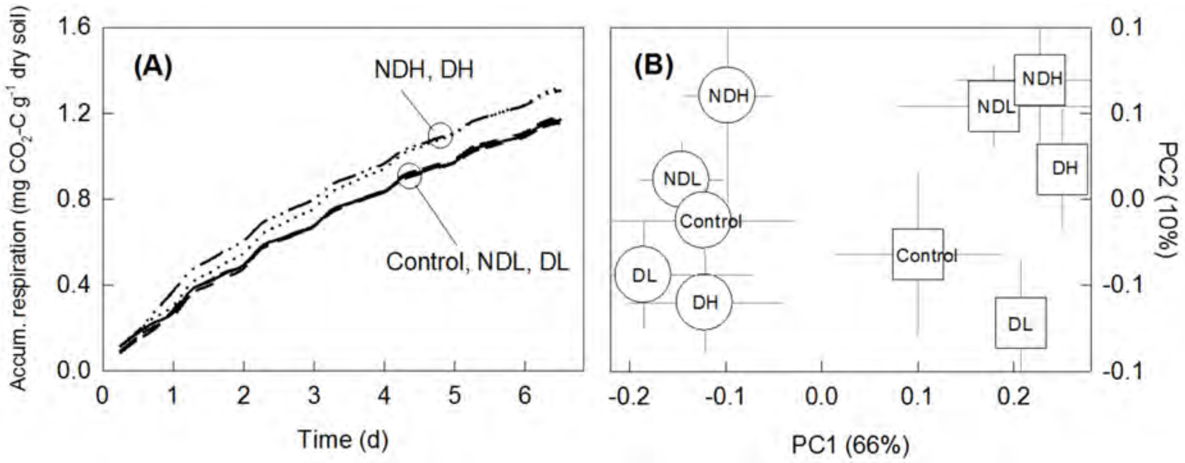

Figure 2. **Microbial (A) accumulated respiration and (B) PLFA profiles (principal component analysis of molar % of individual fatty acids) in soil sampled in field plots without manure (Control), or with low (L) and high (H) applications of digested (D) and non-digested (ND) slurries in spring 2011. Circular and square markers indicate grass-clover and arable systems, respectively, in plot B.**

Although, the PC2 accounts for a minor part (10%) of the explained variation, the non-digested and digested slurries were grouped at opposite ends of this axis. This was observed in both cropping systems, indicating that the digested and non-digested types of slurry had different impacts on the microbiota. Since five days elapsed from application of slurries until soil sampling in 2011, we assume that microbial biomass supplied together with the slurries was decimated by the time of sampling, and did not contribute directly to the PLFA analysis. Microbial diversity and activity are responsible for important ecosystem services, especially in organic farming systems – e.g. degradation power to mobilize nutrients to crops, plant-beneficial microorganisms which can oppose plant pests, and improvement of soil structure. Within the present experimental framework, the soil microbial community seemed to be impacted much more by the cropping system and soil organic matter than by the type of manure. In this respect, manuring with anaerobically digested slurries seems a suitable and safe alternative to untreated cow slurry.

CONCLUSIONS

Anaerobic digestion of dairy cow slurry produces a digestate with slightly lower DM content, but with somewhat higher pH (typically from 7.5 to 8.0) and a proportion of ammonium-N in relation to total N. We found digested slurry to have similar effects on grass-clover ley yields as non-digested, but it reduced clover more than did the non-digested slurry. Our results suggest that a positive yield effect of digested slurry may be achieved in arable crops, provided the slurry is rapidly and well incorporated into the soil, and a crop is rapidly established to utilise the nitrogen. Digested slurry seemed to have less negative effects on earthworms than did non-digested slurry, but in leys earthworms appeared sensitive to the amount of manure applied. Springtails were found in high numbers and with high species diversity and were negatively affected by manure application. Springtails partake in a range of different roles in the turnover of soil organic matter, which is especially important in organic farming systems, and thus they may serve as good indicators of soil quality. Applying digested vs. non-digested slurry affected the microbial community to a much less extent than the differences found between system and the native organic C in the soil. All in all, the use of digestate thus appears a good opportunity to recycle plant nutrients in a system which includes sustainable production of bioenergy. Hence, with respect to soil fertility it appears to be acceptable to recycle plant nutrients combined with production of bioenergy. However, longer time series as well as other types of slurries (anaerobically digested vs. non-digested) and cropping systems needs to be studied in order to establish if the present findings are valid in general.

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PROTEIN CONTENT AND VOLUME WEIGHT OF CEREALS DEPENDING ON LEGUMINOUS PRECROP IN ORGANIC CONDITIONS

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INTRODUCTION

The aim of the trial was to diversify the selection of suitable green manure leguminous precrops and determine their influence to protein content and volume weight of followed cereal crop. The trials were carried out at the Estonian Crop Research Institute in 2011-2013.
The weather conditions of the main trial year (2013) were favourable for high yield and volume weight formation but the protein contents remained comparatively low.

MATERIALS AND METHODS

Two varieties of each cereal crop (barley, oats, rye, spring and winter wheat) were tested in 2013. The 5m² plots were sown in three replications after six different leguminous precrops in organic conditions. Precrops (sown in 2011 and 2012) were lupine, red clover, alsike clover, sweet clover, Alexandria clover (annual), crimson clover (annual) and timothy as standard.

RESULTS AND DISCUSSION

Protein content of all the cereals except winter rye, increased after all the leguminous species compared to standard. Studies by Doltra *et al* (2011) confirm that leguminous green manures have a positive effect on protein content in the organic systems. As average of all the leguminous precrops the increase of protein content was equal for oat, winter and spring wheat (1,1%) but somewhat less for barley (0,7%). The growth was low after annual Alexandria and crimson clover (respectively 0,2 and 0,3%). The maximum increase had spring wheat after alsike clover by 2,6%. As average of all the cereals the highest rise in protein content was after alsike and red clover.
The volume weight of all the cereals increased after the leguminous precrops as average by 2,0 to 5,5%. Increase of volume weight was recorded also by L. Talgre (2013). The highest increase had rye and oat. The extent of increase in volume weight was different after legume species.
As average of cereals the highest growth had after alsike clover by 4,2%. The effect of red clover was the lowest among the precrops.

CONCLUSIONS

Alsike clover increased protein content and volume weight the most as average of all the cereals. The lowest effect to protein content had annual clovers and to volume weight red clover.

Key words: *leguminous precrop, cereal, protein content, volume weight, organic management.*

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BIOMASS PRODUCTION AND NITROGEN UPTAKE OF DIFFERENT GREEN MANURE AND CATCH CROPS ON FINNISH ORGANIC VEGETABLE FARMS

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Abstract. *Green manure and catch crops are main tools in the maintenance and improvement of soil fertility in organic farming. What are the above-ground dry matter yields and nitrogen uptake efficiencies of different green manure and catch crops? These issues were investigated in 2013-2014 on five organic vegetable farms locating in different parts of Finland. In 2014, the catch crop experiment was established to the organic vegetable field plot where broccoli was harvested at the end of July and four different catch crops were sown in mid-August.*

A green manure mixture of white clover (Trifolium alba)-timothy grass (Phleum pratense)-Italian rye-grass (Lolium multiflorum) gave the highest dry matter (DM) yield, 15 265 kg ha^{-1} and nitrogen yield, 362 kg ha^{-1} in the second year after sowing. Mixtures of white sweet clover (Melilotus albus)-timothy grass and red clover (Trifolium pratense)-timothy grass gave also high dry matter yields in the second year, 10 454 kg h^{-1} and 9 990 kg ha^{-1}, respectively. Nitrogen yields were 161and 134 kg ha^{-1} respectively. The second year yields of perennial white sweet clover were 8493 kg DM ha^{-1} and 206 kg N ha^{-1}. The dry matter yield of commonly cultivated mixture of mustard (Sinapis sp.)-pea (Pisum sativum) varied from 4094 to 5387 kg ha^{-1} depending on farm and a year. The nitrogen yield of mustard-pea mixture was on an average 110 kg ha^{-1}. There was a significant difference in the dry matter produced from mid-August until mid-October by the four tested catch crops. White mustard (Sinapis alba) produced the highest dry matter yield, 1416 kg ha^{-1}. Phacelia (Phacelia tenacetifolia) produced 933 kg DM ha^{-1} but the Italian rye-grass (Lolium multiflorum) and fodder radish (Raphanus sativus L. var. oleiformis) showed a very low biomass production (277-291 kg DM ha^{-1}). The nitrogen yields of white mustard and phacelia were 57 kg N ha^{-1} and 33 kg N ha^{-1}, respectively.

This data increases the understanding of the different capacities of green manure and catch crops to produce biomass and take up nitrogen in the northern climate conditions. The results can be utilized in the designs of crop rotation and nitrogen management on organic vegetable farms.

Key words: *green manure, catch crop, dry matter yield, nitrogen, organic vegetable farming.*

CROP SCIENCE AND PRODUCTION

RECURRENT INOCULATION OF SOYBEANS IS NOT NECESSARY

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Abstract. *Soybean is a legume used world-wide for food and fodder. It fixes atmospheric nitrogen and symbiotically produces high quality protein, and is therefore a valuable crop to include in any crop rotation. Currently Sweden imports large quantities of soybean, notwithstanding the negative impact on the environment, owing to, e.g., deforestation in countries where soybeans are produced and the use of long transportation routes. When cultivating soybeans on juvenile soils, which are common in Sweden, they need to be inoculated with their symbiotic partner, the bacteria Bradyrhizobium japonicum. Task of the present study was to investigate the need for re-inoculation of soybeans in cropping sequences where soybeans are included. For this purpose we collected samples from soils in which soybeans had been grown previously and used these soils to grow soybeans in a greenhouse. We found that B. japonicum survived in the soils in which soybeans had been grown previously. Soil factors such as pH, nitrogen content and organic matter showed varying and inconsistent effects on the survival rate of B. japonicum, making it difficult to estimate their impact significance. However, application of nitrogen (as manure) and high amounts of phosphorus in soil appeared to promote B. japonicum survival. The amount of potassium in soil had varying effects, but high amounts appeared to impair B. japonicum survival. As regards to soil type, B. japonicum survived better in light soils than in clayey soils. We conclude that it could be recommended for growers not to re-incoulate their soybeans if the crop has been cultivated in recent years.*

Key words: *cropping sequences, Bradyrhizobium japonicum, re-inoculation, sustainable production.*

INTRODUCTION

Soybean has the ability to fix atmospheric nitrogen for producing high quantity and quality protein. This feature makes the crop suitable as a food and fodder; it is also a welcome feature in the cropping sequence [1]. In Sweden, soybean is not cultivated to a great extent, therefore Sweden relies on import. In 2011, soybean was the second largest food import in Sweden, comprising about 250 thousand tons valued at approx. 125 million USD, aimed primarily as animal fodder. Importing soybean has a negative impact on the environment through, e.g., deforestation and long transportation routes before arriving in Sweden. To counteract this, the interest in growing soybean in Sweden has increased. To ensure that an effective nitrogen-fixing symbiosis establishes, farmers need to inoculate soybean seeds with *Bradyrhizobium japonicum* before sowing. Inoculation is simply done by applying *B. japonicum* directly onto the seeds. It is currently considered necessary to re-inoculate soybean seeds with *B. japonicum* each time the crop is to be grown to ensure the symbiotic nitrogen fixation to be established.This raises the question amongst growers whether annual inoculation is really necessary. A report has shown that *B. japonicum* bacteria are unable to survive in prairie soils in Canada [2]. Given this background, the aim of the presented work was to investigate if *B. japonicum* is able to survive in the soils of Sweden after a soybean crop, in order to give advice to growers regarding the necessity to re-inoculate soybeans in a cropping sequence including soybeans.

MATERIALS AND METHODS

Soil sampling and field management history

Soil samples were collected in 2014 from the following farms:

- Munktorp (N 59°32.301’, E 16°8.604c), sampling conducted from fields where soybean had been grown during 2011 and 2013;
- Sjöö (N 59°42.616’, E 17°30.293’), sampling conducted from three fields where soybean had been grown in 2011, 2012 and 2013;

- Edsberg (N 59°22.391', E 13°15.022'), sampling conducted from fields where a soybean crop had been grown in the previous year (i.e. 2013);
- Berga (N 59°11.433', E 14°52.910'), sampling conducted from fields where a soybean crop had been grown in the previous year (i.e. 2013).

Soil samples were taken from the topsoil (0-20 cm depth). A total of 20-30 samples of 1-2 L soil, each consisting of 5-6 subsamples, were collected randomly diagonally at each field. Immediately after collecting the soil, samples were mixed with pumice stone in order to avoid compact soils, and placed in pots comprising 1.3-1.4 L soil and 0.6-0.7 L pumice stone. Five soybean seeds, cv. Moravians, were then placed in each pot. Conditions set for the soybeans were 20^{o}C, light intensity of 250-350 µmol m^{-2} s^{-1}, duration of light 17 hours/day and humidity 60%. No additional nutrients were applied to the plants during growth. After seedling emergence, plants were thinned to give two plants per pot. Manual watering was performed when necessary. Plants were harvested after two months of growth. Above ground plant material and nodules were separated, dried and weighed. The soil from each field was analysed for pH value and content of nitrogen, phosphorus, potassium and carbon using standard procedures.

Statistical analysis

For each experiment mean values of each treatment were calculated and compared with each other using the two-sample t-test, using Minitab program [3].

RESULTS AND DISCUSSION

All collected soil samples contained *B. japonicum*, since all soybean plants produced nodules (Table 1).

Table 1

Symbiotic efficiency of *Bradyrhizobium japonicum* in soils where soybeans were cultivated the previous year (2013)

Location	Nodule weight (g)	Plant biomass weight (g)	Nitrogen content in plant biomass (%)
Berga	0.42 ± 0.04C	15.0 ± 1.10B C?	3.12 ± 0.16D
Edsberg	0.40 ± 0.02C	13.6 ± 0.62B C?	2.87 ± 0.12C
Munktorp	0.26 ± 0.01B	10.8 ± 1.20B	2.27 ± 0.06B
Sjöö	0.14 ± 0.01A	6.48 ± 0.84A	2.55 ± 0.08A

Different letters indicate that the mean values (n=7) are significantly different.

The soil at Munktorp, in which soybean had been grown previously in 2011 and 2013, still contained *B. japonicum*, since all plants in each treatment produced nodules. There were no differences between years in terms of nodule weight or plant biomass weight. This indicates that there was a similar amount of surviving *B. japonicum* in the soils independently of for how long ago soybeans had appeared on the site (Table 2). As shown, nitrogen content in plants were higher in plants forming nodules with bacteria which has been able to survive for at least some years after the introduction.

Table 2

Symbiotic efficiency of *Bradyrhizobium japonicum* in soils at Munktorp where soybeans were cultivated in 2011 and 2013 respectively

Year of last soybean cultivation	Nodule weight (g)	Plant biomass weight (g)	Nitrogen content in plant biomass (%)
2011	0.24 ± 0.02	7.46 ± 0.51	3.41* ± 0.08
2013	0.19 ± 0.03	8.65 ± 0.95	3.06 ± 0.16

Asterisk (*) indicates significant differences between mean values (n=7).

Similarly, soils from Sjöö with soybeans grown previously in 2011, 2012 and 2013 all contained *B. japonicum*, as plants grown in these soils were able to produce nodules. There were no differences between the soils in terms of nodule weights. However, there were differences regarding to plant biomass weight and nitrogen content (Table 3). The lowest biomass was obtained in soil with soybeans grown in 2013, and the highest nitrogen content was achieved in plants grown in a soil cultivated with soybeans a year before.

Table 3

Symbiotic efficiency of *Bradyrhizobium japonicum* in soils at Sjöö where soybeans were cultivated in 2011, 2012 and 2013 respectively

Year of last soybean cultivation	Nodule weight (g) ± SE	Plant biomass weight (g) ± SE	Nitrogen content in plant biomass (%)± SE
2011	0.53 ± 0.05	15.1 ± 1.00	2.71 ± 0.12
2012	0.34 ± 0.03	11.4 ± 1.10	3.01* ± 0.10
2013	0.19 ± 0.02	8.60* ± 0.54	2.81 ± 0.17

Asterisk (*) indicates significant differences between mean values (n=7).

As presented, *B. japonicum* were present in all soils, since the plants in all soils produced nodules (Tables 1-3). As shown, the bacteria were able to survive in soil after two years, which contradicts with previous study [2] where it was found that *B. japonicum* was unable to survive in Canadian soils. The reason of the discrepancy could be due to current soil characteristics. Soil characteristics, such as pH, have been shown to affect *B. japonicum*. The bacteria have been shown to prefer higher pH [4]. In our study a trend was found between soil pH at the sites and biomass, and nodule weights (Figure 1).

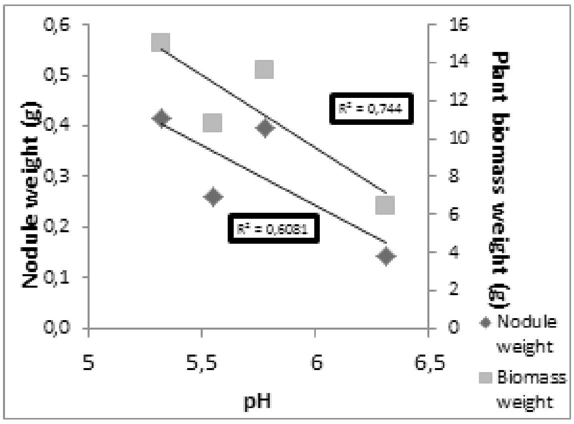

Figure 1. **The effect of soil pH on nodule dry weight and plant dry biomass of soybean grown in soils where soybean had been grown a year before previously (2013)**

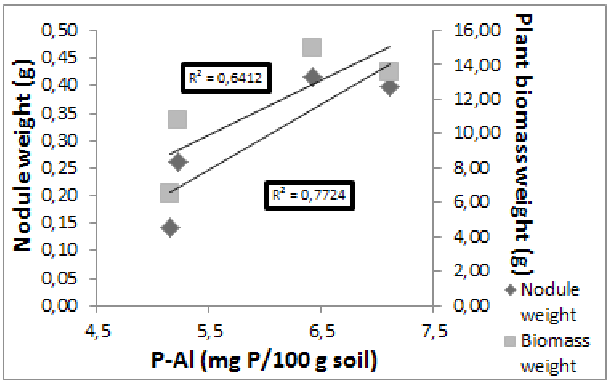

Figure 2. **Effect of plant available phosphorus (P-AL) on nodule dry weight and plant dry biomass of soybean grown in soils where soybean had been grown a year before previously (2013)**

There were no correlations between nodule weight and plant biomass weight, and soil nitrogen and carbon content (data not shown). This observation could not be confirmed since there are no previous reports available on of how soil organic matter and nitrogen in soil affect *B. japonicum*. Analysis on the relationship between plant available P (P-AL) phosphorus (P) and survival of *B. japonicum* indicates that plant available P may have an impact on the nodule weight and plant biomass (Figure 2). However, strongly bound soil P did not affect those parameters (data not shown). Our observations are supported by previous studies [5],[6], showing that higher soil phosphorus concentration promotes growth of *B. japonicum* and therefore soybean plants. Based on these results, we suggest that increased amount of phosphorus in soil increases the survival rate of *B. japonicum*.

Contrary to the beneficial effect of P on bacteria survival, potassium (K) negatively affects the survival of bradyrhizobia (Figure 3). Premaratne & Oertli [6] found that increased K concentration increased plant dry matter and nodule weight, which contradicts with our results. We further tested if the negative impact of K might be related to the soil texture, but this was not confirmed (data not shown). A better survival rate of *B. japonicum* has been observed in lighter soil rather than in loamy textured soils [7].

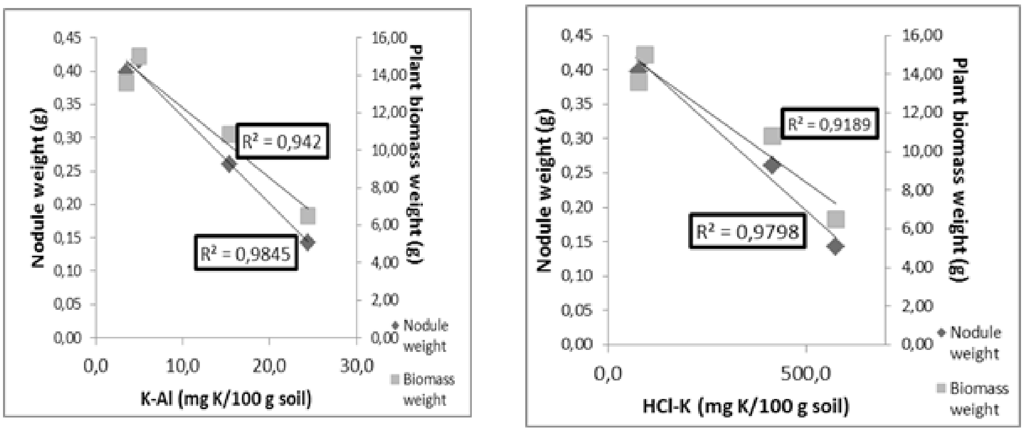

Figure 3. **Effect of plant available potassium (K-AL) (left) and strongly bound potassium (K-HCl) (right) on nodule dry weight and plant biomass of soybean grown in soils where soybean had been grown a year before previously (2013)**

CONCLUSIONS

B. japonicum is able to survive in the soils in which soybeans had been grown previously.

Soil factors, such as pH, nitrogen content and organic matter, have varying and inconsistent effects on the survival rate, making it difficult to estimate their impact.

Fertilization with phosphorus promotes *B. japonicum* survival.

High rates of potassium in soil appear to impair *B. japonicum* survival.

It could be recommended for growers not to re-inoculate their soybeans if the crop has been cultivated in recent years.

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THE EFFECT OF SYMBIOTIC ASSOCIATIONS ON THE PRODUCTIVITY OF *VICIA FABA* L. AND *PISUM SATIVUM* L.

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Abstract. *Legumes are economically important crop, and yearly increase of legume crop areas can be observed not only in Latvia, but also throughout the world. Legumes are high-quality, protein-rich animal feed and wholesome source of nutrition for people. Moreover, they are valuable crop in different crop rotation systems. Legume productivity largely depends on the successful formation of the symbiosis between the plant and soil microorganisms. The most important among these microorganisms are Rhizobium leguminosarum and mycorrhiza fungi. An experiment was performed in order to evaluate the effectiveness of two Rhizobium leguminosarum strains separately and in association with the mycorhiza fungi on the growth and productivity of legumes. This experiment was supported by EU 7th frame EUROLEGUME project (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed). Rhizobium leguminosarum strains (RL23 and RL407) were taken from the collection of Latvia University of Agriculture, but mycorrhiza fungi were received from Czech company "Symbiom". Field experiments were conducted using grey pea (Pisum sativum L.) cultivar 'Retrija' and broad bean (Vicia faba L.) cultivar 'Bartek'. Seeds were treated with bacteria suspension before sowing, while mycorrhiza fungi suspension was applied during sowing. Control plants were not treated with any microorganisms. Plant length, dry matter formation and weight of nodules were analyzed at the flowering stage, while number of pods, seed yield and protein content in seeds - at the end of experiment. Experiments were done in four replications. Data were tested by Analysis of Variance, using Student criteria and correlation analysis between plant growth parameters and protein content in seeds. Results showed differences in plant growth and yield between both legume species using co-inoculation with Rhizobium leguminosarum strains and mycorrhiza fungi. Fresh weight and dry weight of the plants did not show any significant differences between microorganism treatments. A trend was observed that suggested the use of both strains of rhizobia (RL23 and RL407) together with mycorrhiza fungi on beans, while another trend suggested the use of rhizobium strain RL407 in the case of peas. Broad beans showed higher response to co-inoculation than grey peas. Correlation analysis found a medium correlation (r=0.52) between plant and nodule weight. The co-inoculation of rhizobia and mycorrhiza fungi enhanced protein accumulation in the seeds of broad bean, although the degree of influence varied between rhizobium strains; therefore, it is crucial to find compatible components for the co-inoculation.*

Key words: *rhizobia, mycorrhiza fungi, protein, legumes.*

APPLICATION OF BIOTECHNOLOGY METHODS IN CEREAL BREEDING IN LATVIA

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Abstract. *Different biotechnology methods are developed to enhance crop breeding process, including marker assisted selection, cloning, inducing variability of the source material etc. Among those methods most applicable from practical point of view is producing of doubled haploid (DH) lines from breeder hybrids. DHs are homozygotic, not segregating lines, which allowed true breeding, including for traits, determined by recessive alleles of important genes, starting already of the first generation. In result, breeding time of new varieties is shortened for several years with remarkable economy of labour and different other expenses. Collaboration between the Institute of Biology and breeding institutions in cereal breeding are in progress more than ten years. Doubled haploid lines are produced from breeders' hybrids by use of the haploproducer* Hordeum bulbosum *(barley), or by both microspore and anther cultures (barley, wheat, triticale). The new varieties of barley 'Austris' and spring wheat 'Robijs' were created in collaboration with the State Stende Cereal Breeding Institute from DH lines and officially registered.*

Key words: *doubled haploids, barley, wheat, varieties.*

RELATIONSHIPS OF SPRING BARLEY QUALITY CHARACTERISTICS WITH ENVIRONMETAL CONDITIONS

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Abstract. *The duration of cereal growth depends strongly on temperature and precipitation therefore these are one of the most important factors affecting grain quality. This study investigated effects of environment on variation of spring barley (Hordeum vulgare L.) grain quality characteristics. Five morphologically and phenologically different varieties of Latvian origin including three covered (Ansis, Idumeja, Austris) and hulless ones (Irbe, Kornelija) were grown during 8 growing seasons (2007-2014) at the State Stende Cereal Breeding institute where detailed climatic data about mean daily temperature and precipitation were being collected during three months from May to July. Grain chemical composition (crude protein, starch and total β-glucans concentration) was evaluated by Infratec 1241. Results were subjected to analysis of variance and Pearson phenotypic correlations of spring barley quality characteristics with climatic data were calculated across all environments for each genotype, they were pooled and their homogeneity determined. Genotypic means of grain quality characteristics indicated that the hull-less variety 'Kornelija' ranked highest in protein content (148.2 g kg^{-1}) and β-glucans (50.5 g kg^{-1}) content. Environmental variation for crude protein was from 114.8 to 151.4 g kg^{-1}, for starch from 606.6 to 628.4 g kg^{-1}, but for β-glucans from 40.2 to 51.2 g kg^{-1}. Crude protein content was correlated posetively with high temperature and drought conditions in the beginning of both June and July. High precipitation amount at the third decade of both June and July stimulated the accumulation of starch. High precipitation in May and its deficiency in the first decade of July were correlated posetively with total β-glucans content. The correlations coefficients were not homogenous across covered and hulless genotypes related to effect of temperature on development of β-glucans. The accumulation of β-glucans significantly possitively effected by warmer temperature in May for hulless barley, and in the first decade of July for covered barley.*

Key words: *spring barley, environment conditions, grain quality, correlation.*

POSSIBILITIES OF USING COVER CROPS IN CLAY LOAM SOILS OF NORTHERN LITHUANIA

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Abstract. *A range of experiments were conducted at Joniškėlis Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry in 2010-2014 with the view of establishing the possibilities of cover crop cultivation and utilization in clay loam Cambisol. The influence of the main and cover crop combinations, straw and fertilization intensity; organic, sustainable and intensive cropping systems with cover crops in the soils of different humus content and reduced tillage combinations with cover crops on plant productivity was investigated. It was established that the most abundant yield was achieved when growing field pea after white mustard which can reduce the amount of free nitrogen in soil and stimulate the fixation of biological field pea nitrogen. The maximum yield of spring oilseed rape was obtained while fertilizing with mineral NPK fertilizer. The straw used as fertilizer reduced plant productivity, the cover crop cultivation mitigated its negative effect inducing straw degradation and nitrogen fixation in organic compounds. The incorporation of cover crop mass in combination with farmyard manure in the sustainable cropping system determined a significant increase in field pea yield compared with the organic system. The yields of winter wheat and field pea were higher in the intensive cropping system compared with the organic one. The yields of winter wheat and field pea in the soil of moderate humus content were higher compared with that in the soil of low humus content. Leaving of cover crops as mulch over winter without any tillage in autumn resulted in the decrease of field pea yield compared with ploughless tillage alone. Spring oilseed rape was less sensitive to the reduction of tillage in the combinations with cover crops compared with field pea.*

Key words: *cover crops, crop yield, cropping systems, fertilization intensity, tillage.*

INTRODUCTION

The abundance of clay particles in the clay loam soils of limnoglacial origin determines greater sorptive capacity and higher stability of nutritive elements and the productivity of crop rotation plants compared with light soils [1]. However, the global climate change and the effects of intensive agriculture on the environment invite to become worried about soil matching economic benefit with the management and conservation of natural resources [2]. One of the remedies is cover crop cultivation. In Lithuania soil is covered with the main crops only for 60-70% of the warm period. During the rest of the time the soil uncovered with plants is damaged by different environmental factors: dried by the sun and wind, the structure is damaged by heavy rainfall. Due to the above reasons microbiological processes in soil are suppressed, nutrients migrate downwards and weeds, especially perennial ones, prevail [3]. Cover crop cultivation improves nutrient management [4] and reduces the losses of nitrogen and other elements into the environment [5], it allows the reduction of mineral fertilizer rates [6] and improves the phytosanitary condition of crops [7]. These plants can loosen biologically a densified, mechanically unloosened soil layer by strong roots and thus improve soil structure [8]. However, the influence of cover crops on the productivity of crop rotation plants is not homologous. It depends on various factors. The mass of cover crop plants, the amount of nutrients (especially that of nitrogen) accumulated in it, the depth, ways and time of its incorporation into soil, soil and climate conditions determine the intensity of plant mass decomposition, release of chemical elements and other various biochemical processes in soil [9]. Additional yield can be expected only when the release of nutrients from the incorporated plant mass agree with the needs of plants grown with the main crops under the minimal activity of other biochemical processes taking place in soil.

The objective of this research was to establish the influence of the combinations of different types of plants grown as the main and cover crops, fertilization intensity and tillage methods on plant productivity.

MATERIALS AND METHODS

Experimental site and soil

Field experiments were conducted at the Joniškėlis Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry (LRCAF) in 2010-2014. The station is situated in the northern part of Central Lithuania's lowland (40-60 m above the sea level; latitude: 56°12" N; longitude: 24° 20"). Northern Lithuania has a climate mid-way between maritime and continental. The climate is changeable, with mild, wet summers and cold winters. Annual precipitation is 500-600 mm. The soil of the experimental site is *Endocalcaric Endogleyic Cambisol* (*Siltic*, *Drainic*). The soil according texture is clay loam on silty clay with deeper lying sandy loam. The parent material is glacial lacustrine clay, which at 70-80 cm depth transits into morainic loam. Clay (< 0.002 mm) in the Ap horizon (0-30 cm) account for 27.0%, in the B_w horizon (31-51 cm) 59.6%, in the B_k horizon (52-76 cm) 51.6%, in the C_1 horizon (77-105 cm) 10.7%, in the C2 horizon (106-135 cm) 11.0%. Soil bulk density in the plough layer (0-25 cm) is 1.3-1.4 Mg m^{-3}, total porosity is 40-45%, and air-filled porosity is 8-10%. At the beginning of the experiments, soil agrochemical properties at the 0-20 cm layer varied: pH –6.1-7.1, available phosphorus (P_2O_5) – 115-182 mg kg^{-1}, available potassium (K_2O) – 172-268 mg kg^{-1} (content of P_2O_5 and K_2O was determined by Egner-Riehm-Domingo (A-L) method), humus 1.90-2.91%.

Influence of cover crops, straw and fertilizing intensity on plant productivity

Seeking to ascertain the effects of various main and cover crop combinations, straw and fertilization intensity on main crops productivity was done in a three-factor experiment set up in 2013, and the effects of measures used was monitored for successive year 2014. *Experimental design:* factor A – main and cover crop combinations: 1) spring barley (*Hordeum vulgare* L.) without cover crop – spring oilseed rape (*Brassica napus* L. (Partim)); 2) spring barley with undersown red clover (*Trifolium pratense* L.) – spring oilseed rape; 3) spring barley without cover crop – field pea (*Pisum sativum* L. (Partim)) ; 4) spring barley with post sown white mustard (*Sinapis alba* L.) – field pea ; factor B – straw use: 1) removed, 2) spread (+N_{40}); factor C – fertilization intensity: 1) unfertilised, 2) sustainable fertilizing, 3) intensive fertilizing. Red clover cv.'Vyliai' (seed rate 15 kg ha^{-1}) was undersown into spring barley in spring. After cereal harvesting straw was removed or chopped and spread. White mustard cv. 'Signal' (seed rate 18 kg ha^{-1}) was sown on the day of spring barley harvesting. For optimal growth of white mustard (when straw was removed or chopped and spread) and for straw mineralization, ammonium nitrate (40 kg ha^{-1} N) was applied. Late in autumn, due to better incorporation of cover crops, their biomass was chopped by disk stubble breaker and ploughed in at the 25 cm depth. The effect of cover crops mass were investigated in the folloving year for field pea cv. 'Tinker' (seed rate 380 kg ha^{-1}) and spring oilseed rape 'Kaldera' (seed rate 6 kg ha^{-1}). Fertilization rates were calculated according to agrochemical soil properties and the planned crop yield. The experimental plots were laid out in a complete three-factor randomised block design in four replicates.

Influence of cropping systems on plant productivity in soils of different humus content

Organic, sustainable and intensive cropping systems on a soil with different humus content, their effects on the sustainability of major crop productivity in the crop rotation – spring barley + undercrop → perennial grass (red clover) → winter wheat (*Triticum aestivum* L.) → field pea were investigated. *Experimental design:* soil humus content – factor A: low (1.90-2.01%); moderate (2.10-2.40%). Cropping systems – factor B: Organic*:* red clover cv. 'Vyliai' (15 kg seed ha^{-1}) mass as green manure was applied for winter wheat cv. 'Ada' (240 kg seed ha^{-1}), winter wheat straw was applied as manure and the cover crop – blue lupine (*Lupinus angustifolius* L.) cv. 'Boruta' (120 kg seed ha^{-1}) in a mixture with oilseed radish (*Raphanus sativus* var. *Oleiferus* Metzg.) cv. 'Rufus' (20 kg seed ha^{-1}) was cultivated as green manure for field pea cv. 'Pinochio' (380 kg seed ha^{-1}). Sustainable: farmyard manure (40 Mg ha^{-1}) was applied for winter wheat, winter wheat straw was applied as manure + mineral N fertilizer (N_{30}) in the form of ammonium nitrate for straw decomposition in autumn and white mustard cv. 'Sinus' (20 kg seed ha^{-1}) in a mixture with buckwheat (*Fagopyrum esculentum* Moench.) cv. 'Smuglianka' (80 kg seed ha^{-1}) was cultivated as green manure for field pea. Intensyve: red clover biomass as green manure + mineral fertilizer $N_{30}P_{60}K_{60}$ was applied for winter wheat, winter wheat straw as manure + mineral N fertilizer (N_{30}) for straw decomposition in autumn and mineral fertilizer $N_{10}P_{40}K_{60}$ in spring was applied for field pea. The experimental plots were laid out in a complete two-factor randomised block design in four replicates.

Effect of cover crop management under reduced tillage conditions

The experiment examined the effects of reduced tillage ant its combinations with cover crop management on main crop productivity. *Experimental design:* 1) ploughless tillage at 10-12 cm depth; 2) ploughless tillage at 10-12 cm depth with cover crop incorporation for green manure; 3) cover crop for winter mulch without tillage in autumn. Main crop rotation: field pea → winter wheat → spring oilseed rape → spring barley. The pre-crop (spring barley for field pea and winter wheat for spring oilseed rape) straw was chopped during harvesting and incorporated into the soil at 8–10 cm depth during stubble cultivation. Post-harvest cover crops were the mixture of white mustard cv. 'Braco' (10 kg seed ha^{-1}) and oilseed radish cv. 'Rufus' (13 kg seed ha^{-1}) for field pea after spring barley and the mixture of field pea cv. 'Klif' (90 kg seed ha^{-1}), common vetch (*Vicia sativa* L.) cv. 'Aisiai' (50 kg seed ha^{-1}) and blue lupine cv. 'Boruta' (60 kg seed ha^{-1}) for spring oilseed rape after winter wheat. Cover crops were sown after stubble cultivation. Cover crop fertilization – N_{30}. Cover crop for green manure was incorporated into soil by a combined stuble cultivator in autumn. Cover crop for winter mulch was left during winter without any tillage in autumn and its frost killed residues covered the soil surface. Field pea (360 kg seed ha^{-1}) cv. 'Tinker' and spring oilseed rape (7 kg seed ha^{-1}) cv. 'Fenjac' were grown as a main crops. Main crop fertilization: field pea – $N_{30}P_{90}K_{60}$, spring oilseed rape – $N_{120}P_{90}K_{60}$. The trial was arranged as a randomized single row design in four replicates.

Experimental parameters

A randomised plot design was used with the main plot size of 100 m^2 (20.0 m long and 5.0 m wide) and harvested plot size of 32.2 m^2 (14.0 m long and 2.3 m wide).

Plant analyses

The investigated crops plots were harvested using a small plot combine harvester. Grain yield was harvested when the majority of crops had reached hard dough stage (BBCH 87). Plant productivity was established by weighing. Dry matter (DM) content in the organic matter was determined by drying the sample at 105 °C to a constant weight. The grain yield (Mg ha^{-1}) is presented: field pea and winter wheat at 14.0%; spring oilseed rape at 9.0% standard moisture (w/w).

Statistical analyses

The research data were processed by analysis of variance using the program package Selekcija [10]. Sigificant differences are indicated by *$P < 0.05$ and ** $P < 0.01$.

Table 1

Influence of different cover crops, straw and fertilizing intensity on field pea and spring oilseed rape productivity Mg ha^{-1}, 2014

Fertilization intensity (C)	Without cover crop		Cover crops ▼	
	straw use (B)			
	removed	spread (+N_{40})	removed	spread (+N_{40})
Field pea				
Unfertilised (control)	4.90	3.92**	5.07	4.19**
Sustainable fertilizing	5.02	4.23**	5.15	4.64
Intensive fertilizing	5.00	4.03**	5.15	4.61
Mean	4.97	4.06**	5.12	4.48**
LSD_{05}: A – 0.195; B – 0.195; C – 0.238; AxB – 0.275; AxC – 0.337; BxC – 0.337; AxBxC – 0.477.				
Spring oilseed rape				
Unfertilised (control)	1.11	1.10	1.20	1.18
Sustainable fertilizing	1.64**	1.26	1.51**	1.34*
Intensive fertilizing	1.74**	1.46**	1.75**	1.55**
Mean	1.50	1.27**	1.49	1.36**
LSD_{05}: A – 0.088; B – 0.088; C – 0.108; AxB – 0.125; AxC – 0.153; BxC – 0.153; AxBxC – 0.216				

Note: ▼- for field pea - white mustard, for spring oilseed rape - red clover

RESULTS AND DISCUSSION

Influence of cover crops, straw and fertilizing intensity on plant productivity

The cultivation of cover crops and the utilization of their mass and straw as fertilizer had significant influence ($P < 0.01$) on field pea grain productivity (Table 1).

The incorporation of white mustard mass as fertilizer increased field pea grain productivity by 6.3% on average compared with the plot without cover crops. Due to the favourable mass C and N ratio (C:N = 25) white mustard decomposition intensity was low and it released a low amount of soil mineral nitrogen. Soil microorganisms used this nitrogen for decomposing straw and a decreasing amount of mineral nitrogen in soil could determine higher fixation of field pea biological nitrogen and the yield increase. This statement is supported by the fact that the negative influence of straw was substantially lower when field pea had been grown after the incorporation of white mustard mass compared with the cultivation without cover crops. The utilization of spring barley straw as fertilizer reduced pea grain productivity by 15.5% on average. A significant positive influence of phosphorus and potassium fertilizers was established when field pea had been grown after white mustard. An additional yield was higher by 10.5% on average compared with the unfertilized plot (without cover crop). The highest pea grain yield was obtained while growing it after white mustard with spring barley straw removed from the field and having fertilized with PK fertilizer.

Straw, fertilization with mineral fertilizer NPK ($P < 0.01$) and the interaction of these factors ($P < 0.05$) had a significant effect on spring oilseed rape yield. According to the mean data red clover mass only had a tendency of increasing spring oilseed rape yield. Due to narrow C and N ratio (C:N = 15) leguminous grass mass decomposes fast [9]. In accordance with the authors' other research data the incorporation of straw together with red clover mass increased the amount of mineral nitrogen in soil significantly during two years in spring [11]. More pronounced differences of spring oilseed rape yield compared with the incorporation of red clover mass were established only in the plots unfertilized with mineral fertilizer: the yield increased by 8.1% after straw removal from the field and – by 6.3% after spread compared with the control plot. Yield increase tendencies were established through the interaction between the cover crops and straw in the plots fertilized with mineral fertilizer. It can be proposed that some part of the *Fabaceae* mass nitrogen was incorporated into microbial biomass or organic soil compounds. The use of straw as a fertilizer reduced spring oilseed rape productivity by 11.9% on average compared with the plot without straw.

The highest spring oilseed rape yield was achieved by fertilizing with NPK fertilizer: sustainable fertilization – 25.1%, intensive fertilization – 41.4% compared with the unfertilized plot (average data). The highest spring oilseed rape yield was obtained having removed straw from the field and fertilized with the largest NPK rates irrespective of the cover crops.

Influence of cropping systems on plant productivity in soils of different humus content

The red clover mass as green manure and the application of farmyard manure and mineral fertilizers influenced the yield of winter wheat significantly only among the cropping systems ($P < 0.01$). According to the average data of four crop rotation fields due to slow mineralization of organic materials in clay loam soils fertilization with farmyard manure in the sustainable cropping system did not increase winter wheat grain yield significantly compared with the organic system (Table 2). The significantly highest winter wheat grain yield was achieved in the intensive cropping system where both green manure and mineral $N_{30}P_{60}K_{60}$ fertilizer were applied on winter wheat. In this cropping system the winter wheat grain yield in the soils of low and moderate humus content was 15.6 and 16.6% higher respectively compared with the yield in organic system. The winter wheat yield in the soil of higher humus content had an increasing tendency: on average the winter wheat grain yield in all cropping systems was 6.5% higher compared with the soil of low humus content, however, the differences were not significant.

Winter wheat straw was incorporated into soil; after that during the post-harvest period the cover crops were grown in the organic cropping system – low field pea yields were obtained. The straw which had been incorporated into soil was rich in lignin and slow to mineralize: that fact could have had influence as the straw utilized the nitrogen present in the soil as well as according to other authors low phosphorus content of the soil is a limiting factor for nitrogen fixation [1].

The field pea yield varied in terms of the humus content groups ($P < 0.05$) and the cropping systems ($P < 0.01$), there was no interaction between the both factors (A x B). A higher level of humus content had the significant positive 10.4% influence on field pea grain yield in all cropping systems compared with the soil of low humus content. The incorporation of cover crop mass in combination with farmyard manure in the soil of moderate humus content had a more marked influence on the field pea yield: in the sustainable cropping system which included growing white mustard together with buckwheat it increased by 11.1 and 32.0% respectively compared with the organic cropping system. In the intensive cropping system both in the soils of low and moderate humus content a significantly highest field pea yield was established – it constituted 34.0 and 26.7% compared with the organic cropping system.

Table 2

Influence of cropping systems on winter wheat and field pea grain yield Mg ha^{-1}, Mean 2010-2013

Cropping systems (factor B)	Soil humus content (factor A)		Mean factor B
	low	moderate	
Winter wheat			
Organic (control)	4.97	5.05	5.01
Sustainable	4.97	5.27	5.12
Intensive	5.74**	5.88**	5.81**
Mean factor A	5.19	5.37	5.28
LSD_{05}: A – 0.197, B – 0.279, AxB – 0.394			
Field pea			
Organic (control)	1.65	1.72	1.69
Sustainable	1.66	2.27**	1.97*
Intensive	2.21**	2.18**	2.19**
Mean factor A	1.83	2.02*	1.93
LSD_{05}: A – 0.083, B – 0.145, AxB – 0.221			

Effect of cover crop management under reduced tillage conditions

The influence of cover crop utilization and tillage combinations on the field pea grain yield depended on the conditions of a certain year. In 2010 and 2012 which were the years more favourable for field pea cultivation, application of cover crop for winter mulch without any soil tillage in autumn resulted in significantly lower pea grain yield by 19.5 and 37.3%, respectively compared with ploughless tillage alone (Table 3). In 2011, the year which was less favourable for field pea cultivation its grain yield was lower (36.5%) both in the cases of leaving the cover crop mulch over winter without tillage in autumn and also lower (17.8%) having incorporated the cover crop mass in autumn during ploughless tillage. The causes of such yield reduction could be considered to be the sensitivity of field pea to the reduction of tillage and tillage quality in heavy soils. In late autumn the clayey soils covered with cover crops are wetter compared with ones without cover crops. Therefore, under such conditions when green manure is incorporated tillage quality suffers.

Table 3

Effect of tillage and cover crop management on field pea and spring oilseed rape yield, Mg ha^{-1}

Tillage and cover crop management	Year		
	2010	2011	2012
Field pea			
Ploughless tillage	3.89	3.37	4.26
Ploughless tillage with cover crop for green manure	3.59	2.77*	4.09
Cover crop for winter mulch without tillage	3.13*	2.14*	2.67*
LSD_{05}	*0.343*	*0.315*	*0.340*
Spring oilseed rape			
Ploughless tillage	1.98	2.44	1.66
Ploughless tillage with cover crop for green manure	1.85	2.44	1.70
Cover crop for winter mulch without tillage	1.82	2.38	1.48*
LSD_{05}	*0.183*	*0.137*	*0.162*

Our research proved that spring oilseed rape was less sensitive to reduced tillage compared with field pea. Only in 2012 having left cover crop as mulch without any tillage in autumn the yield of spring oilseed rape decreased significantly by 10.8% compared with ploughless tillage alone (Table 3). Therefore, while cultivating spring oilseed rape under reduced tillage conditions more successful utilization of cover crops can be applied.

CONCLUSIONS

1. The field pea grain yield was increased significantly (6.3% on average) by the incorporated white mustard mass compared with the plots without cover crop. It can reduce the amount of free nitrogen in soil and stimulate field pea to fixate biological nitrogen. The highest yield of spring oilseed rape was achieved by applying intensive fertilization with NPK – the additional yield was 41.4% higher compared with the unfertilized plot. The straw used as fertilizer reduced crop productivity: field pea – by 15.5% and spring oilseed rape – by 11.9% compared with the treatment when the straw had been removed from the field. The cultivation of cover crops mitigated its negative impact by stimulating straw decomposition and nitrogen fixation in organic soil compounds.

2. The winter wheat grain yield in the intensive cropping system was significantly higher compared with that in the organic system. A higher level of soil humus content had essential impact on the winter wheat grain yield (increased by 10.0%) compared with that of low humus content soil. The incorporation of cover crop mass in combination with farmyard manure had a marked influence on the field pea yield in the soil of moderate humus content: in the sustainable cropping system where white mustard had been grown together with buckwheat the field pea yield increased by 32.0% compared with the organic cropping system. In the intensive cropping system both in the soils of low and moderate humus content the field pea yield was significantly higher – by 34.0 and 26.7% respectively compared with the organic cropping system.

3. Having left the cover crop as mulch over winter without any tillage in autumn reduced field pea yield by 19.5-37.3% in all years of the investigations compared with only ploughless tillage applied. The incorporation of cover crop as green manure in autumn during ploughless tillage reduced pea yield by 17.8% only in the year less favourable for field pea growing. Due to cover crop utilization as mulch without any tillage in autumn the yield of spring oilseed rape decreased by 10.8% only during one year of the three investigation years. Spring oilseed rape is less sensitive to the reduction of tillage compared with field pea. Therefore, the use of cover crops under the reduced tillage conditions of heavy soil is easier to apply in cultivating spring oilseed rape compared with field pea.

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THE ORIGIN AND ITS EFFECT ON GROWING HABITS OF THE REGROWTH TILLERS OF TIMOTHY AND TALL FESCUE IN FINLAND

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Abstract: *The regrowth of timothy and tall fescue were compared to reveal the origin of different tiller types developing into the regrowth canopy, the recovery potential of different primary growth tiller types after the cut and the effect of primary growth tiller type and developmental stages on regrowth habits. Experiments were conducted during 2006-2009 in Maaninka, Eastern Finland. Tiller type or the final developmental stage of the regrowth tillers in timothy or tall fescue were not determined by the type of tiller in the primary growth, with the exception of generative tillers in the regrowth of timothy originating only from primary growth generative tillers. Thus, tiller type is not an inherited feature of one individual plant and either environmental factors or tiller characteristics determine the final type of the tiller in the regrowth. Recovery potential of different tiller types was contrasting between the species: in timothy, highly developed tillers during the primary growth were had the best survival capacity after cut, but in tall fescue it was the opposite. For obtaining large and rapidly growing tillers into the regrowth, primary growth tillers at advanced elongating vegetative (seven nodes) or early generative stage (before the full emerge of the inflorescence from the flag leaf sheath) in timothy and large vegetative (four leaves) or early generative (inflorescence swollen inside the flag leaf) in tall fescue were the most optimal.*

Key words: *timothy, tall fescue, regrowth, tiller type, tiller feature.*

INTRODUCTION

Harvesting the summer regrowth is an important part of grass silage production in Scandinavia, where only two or three cuts per growing season can be taken. Timothy and different fescues, namely meadow fescue and tall fescue, are the most common forage grasses for silage production in Finland, and their growth habits on the tiller level in the regrowth differ greatly. Especially timothy (*Phleum pratense* L.) and tall fescue (*Festuca arundinaceae* Schreb.) are two contrasting species.

According to visual observations, the regrowth canopy of timothy can consist of three tiller types: vegetative (VEG; containing only leaves and leaf sheaths), elongating vegetative (ELONG; containing true stem and leaves) and generative (GEN; containing true stem, leaves and an inflorescence). On the contrary, tall fescue produces mostly VEG tillers and only few tillers contain true stem in the regrowth. In grasses, there are two alternative means to produce tillers for the regrowth: either continue the growth despite the tiller has been cut if the apex has not been destroyed by the cut, or to form new tiller from the buds nearby the ground level if the apex has been removed or if the primary growth tiller has been seriously damaged in the cut. Tiller type distribution and size in the canopy determine the actual yield of the regrowth sward: in timothy both VEG and ELONG are important in biomass production, while in tall fescue VEG tillers are dominating [1].

If a high regrowth yield with a good feeding value is desired, the tillers should tolerate the cut and recover from it quickly creating a dense canopy, have high rates in tiller length growth, leaf appearance and leaf length growth, resulting in a high total tiller size and abundant amount of living leaf tissue per tiller. In cross-pollinated grass species like timothy or tall fescue, tillers in a sward of a single cultivar are not genetically identical but a population with varying genetical information. Thus, there is variation in the growing habits of individual plants. The developmental stage of tillers during the primary growth cut is supposed to affect the sequential development of regrowth tillers, but only little information is available on which features of the regrowth are determined by the tiller type or developmental stage of the tillers in primary growth.

Our aim in the present study was to compare the regrowth of timothy and tall fescue and reveal: a) the origin of different tiller types developing into the regrowth canopy and the recovery potential of different primary growth tiller types after the cut; b) the effect of primary growth tiller type and developmental stages on regrowth habits. This was done by examining individually marked tillers of timothy and tall fescue after the primary growth cut during four growing seasons in the Nordic climate conditions in Maaninka, Finland.

MATERIALS AND METHODS

The study was conducted during four growing seasons (2006-2009) at MTT Agrifood Research Finland (at present, Natural Resources Institute Finland (Luke)), Maaninka Research Station (68º08´N, 27º19´E). For the studies during growing seasons 2006-2008, the experimental field was established in 2005 and for growing season 2009 in 2008 on fine sand in three replicates by sowing with timothy (cv. Tammisto II) and tall fescue (cv. Retu). During 2006-2009, both experimental fields were cut for the primary harvest before the end of June each year and the second cut was performed in the end of August of each year in order to mimic the standard farming practices of the area. Both experimental fields were fertilized for the primary growth in mid May using 90 kg ha^{-1} of N and for the regrowth immediately after the first cut with using 90 kg ha^{-1} of N. P and K were given according to the soil fertility and typical farming practice of the area. No irrigation or plant protection products were used on either of the field experiments. The data for growing conditions were recorded daily (temperature, precipitation). The effective temperature sum above 0 ºC during regrowth was calculated using the date of the primary growth cut as a zero point.

For tiller measurements, randomly chosen individual main tillers were marked prior to primary growth cut. Tillers were visually determined for the developmental stage and divided into three tiller types as follows:

- VEG. Stages 20-29 according to Simon and Park (SP) [2]; i.e. containing only leaves and leaf sheaths and the number of fully emerged leaves given by the second digit in the SP stage
- ELONG. SP 31-38; tillers containing true stem and leaves and the number of nodes given by the second digit of the SP stage
- GEN. In this study stages SP 45 or higher; tillers containing true stem, leaves and an inflorescence either inside the flag leaf (SP 45) or emerging (SP 50 or higher)

This way, the effect of the developmental stage of the tiller in the primary growth could be taken into account, when measuring the development of tillers in the regrowth. Regrowth tillers were observed visually and measured for SP stage, tiller and leaf appearance, growth and senescence during the regrowth phase approximately once a week (for 6 to 8 weeks and for 8 to 10 times per growing season, depending on the year) until the timepoint of typical regrowth harvest time.

During the regrowth periods of four years, some marked tillers were injured by herbivores or by observational work. In cases where the inclusion of these tillers would distort the results, these tillers were excluded from the data. Results from all years were used and data was not separated by the years, because we did not intend to test the effect of years but merely the effect of developmental stage over the years. To compare timothy to tall fescue, the data was always separated for species.

Recovery potential of tillers was calculated separately for each tiller type class of primary growth using the highest observed SP stage during the regrowth for each tiller, including tillers that did not grow after the primary growth cut. All other parameters were calculated excluding the tillers that had no regrowth.

Growth rate of total tiller height (mm $ºCd^{-1}$) and leaf appearance rate (LAR; mm $ºCd^{-1}$ $tiller^{-1}$) were calculated by dividing the weekly growth or the number of new emerging leaves by the number of accumulated degree days (above 0 ºC) during the past observational interval. Values for LAR were multiplied by 100 for the clarity of results. Total leaf length per tiller (mm $tiller^{-1}$) and senesced leaf length per tiller (mm $tiller^{-1}$) were calculated by adding up the respective values of all leaves inside each tiller. After the weekly observations were calculated, the growth parameters were firstly averaged separately for each tiller to gain a set of independent values for measurements. Secondly, the tiller averages were averaged for the SP stages of the respective primary growth tillers (PG tiller) separately for each tiller type.

RESULTS AND DISCUSSION

We aimed to mark the same amount of primary growth tillers in each tiller type class to obtain a solid dataset, but due to natural differences in the primary growth habits of these species, this was not possible (Table 1). In the primary growth of timothy, all three tiller types were present, but the proportion of VEG main tillers was rather small. In the primary growth of tall fescue, ELONG tillers were almost absent as only three such tillers were found and marked over the four year period of tiller observations. As the number of tillers per tiller type class do not present the actual tiller type distribution in the primary growth canopy, our results in this paper do not describe the actual tiller type distribution in the regrowth, but the a) origin of different tiller types developing into the regrowth canopy; b) the effect of primary growth tiller type to regrowth habits. Nevertheless, the distribution, size and longevity (i.e. the tiller life span over the regrowth period) of the tillers determine the effect of different tiller types on the formation of both yield and feeding quality. The actual distribution and potential of biomass production of these tiller types in the same field experiment has been evaluated by Virkajärvi et al. [1] and the feeding value by Pakarinen et al. [3].

The origin of different tiller types in the regrowth

During the summer regrowth the canopies of timothy consisted of all three tiller types: VEG (developmental stages 20-29 according to Simon and Park (SP) [2], ELONG (SP 31-38, respectively) and GEN (SP 45 or higher, respectively) (Table 1). On the contrary, tall fescue produced mostly VEG tillers and only few tillers contain true stem in the regrowth. In both species, tillers that ended up as VEG in the regrowth originated from all primary growth tiller types. There was no difference inside the species in the average developmental stage (i.e. number of leaves) of VEG tillers originating from different primary growth tiller types, but in timothy there was on average 3 living leaves per tiller (SP 23) and in tall fescue 2 leaves (SP 22).

Table 1

Highest observed developmental stages and recovery potential (% of the initial primary growth tiller type class) of tillers during the summer regrowth of timothy and tall fescue according to their tiller types in both primary growth (PG) and summer regrowth. Developmental stages according to Simon & Park (SP) [2]. VEG = vegetative, ELONG = elongating vegetative, GEN = generative, *n* = number of tillers.

Tiller type in the primary growth	Tiller type in the summer regrowth	Timothy				Tall fescue			
		Developmental stage (SP) in the regrowth		Recovery %	*n*	Developmental stage (SP) in the regrowth		Recovery %	*n*
		Average	max			Average	max		
PG-VEG	**no regrowth**	**0**	0		*13*	**0**	0		*1*
	VEG	**23**	24	36	*10*	**22**	24	98	*43*
	ELONG	**35**	36	18	*5*	**.**	.	0	*0*
	GEN	**.**	.	.	*0*	**.**	.	.	*0*
	all			54	*28*			98	*44*
PG-ELONG	**no regrowth**	**0**	0		*11*	**0**	0		*1*
	VEG	**23**	24	59	*19*	**22**	22	33	*1*
	ELONG	**34**	34	6	*2*	**31**	31	33	*1*
	GEN	**.**	.	.	*0*	**.**	.	.	*0*
	all			66	*32*			67	*3*
PG-GEN	**no regrowth**	**0**	0		*2*	**0**	0		*24*
	VEG	**23**	25	70	*30*	**22**	22	27	*9*
	ELONG	**33**	34	21	*9*	**.**	.	0	*0*
	GEN	**59**	60	5	*2*	**.**	.	0	*0*
	all			95	*43*			27	*33*

In timothy, also ELONG tillers in regrowth originated from all primary growth tiller types, but in tall fescue the only ELONG tiller observed originated from an ELONG primary growth tiller. In timothy the most developed ELONG tillers (SP 35) originated from primary growth VEG tillers and the less developed from primary growth GEN tillers (SP 33). The size (above ground weight or height) of the primary growth tillers producing ELONG tillers in the regrowth did not explain this. It is possible, that the large ELONG tillers in the regrowth originating from VEG tillers, have started their apical transition from VEG to ELONG or GEN before the primary growth cut, but the actual stem elongation was realized after the cut during regrowth.

GEN tillers in the regrowth of timothy originated only from GEN primary growth tillers and were almost flowering in the end of the observation period (SP 59-60). As a long-day grass species, timothy does not obligatorily need a new vernalization for reflowering [5]. In Maaninka, Finland, the day length during the regrowth period was between 15-19.5 h during the experimental years, which is enough for timothy to obtain the induction for flowering. Another explanation for the appearance of GEN tillers into the regrowth canopy is the movement of molecular flowering inducers to other tillers in the same plant through the basal tissues, which has been shown to happen in some grasses [4].

However, there was no clear correlation between the type of primary growth tiller and the type of regrowth tiller in the same plant (data not shown), mostly because most of the tillers in the regrowth reached only VEG stages. This points out that the tiller type is not – at least not fully – a genetic trait or inherited feature in either of the species, and that other factors must affect strongly on the final type of the tiller in the regrowth.

Recovery potential after the primary growth cut

There was a clear difference between the species in the recovery potential of different primary growth tiller types after primary cut. In timothy, only half of all primary growth VEG tillers were able to regrow, while two-thirds of ELONG and nearly all GEN primary growth tillers were able to produce tillers in the summer regrowth (Table 1). In tall fescue, this was quite the opposite, as nearly all primary growth VEG tillers regrew and only a quarter of primary growth GEN tillers formed regrowth tillers. The difference between the two species is due to their different strategies in the onset of regrowth: in tall fescue, most primary growth VEG tillers just continued with their leaf growth despite the cut, but in the primary growth of timothy VEG tillers were very small and were apparently fatally injured in the cut [6].

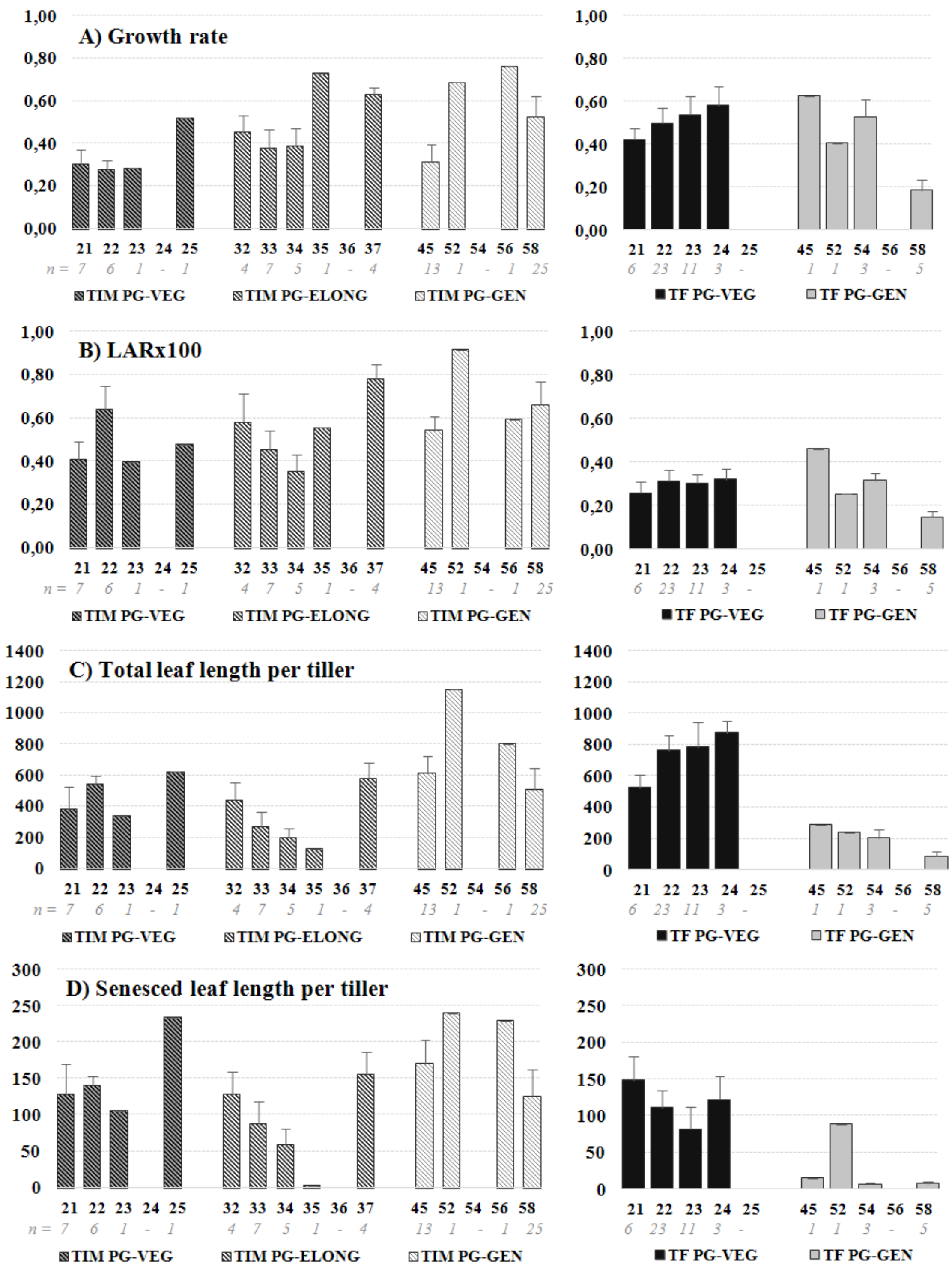
Primary growth ELONG and GEN tillers have to produce their regrowth through new tillers from side buds near the ground level, and in this process it is essential for the tiller to have good reserves of carbohydrate in the remaining stubble and root [7]. In timothy, this is leads to a solid regrowth canopy after a lag phase during the initiation of visual regrowth and the recovery potential seems to be higher on more developed primary growth tillers. In tall fescue these new sidetillers tend to suffer from shading of the already steadily regrowing leaves (of primary growth VEG tillers) and are not as successful as the ones in timothy.

Growth habits of the regrowth tillers originating from different primary growth tiller types

Regrowth of tillers is suspected to be more vigorous, if the concerned primary growth tiller has reached higher developmental stages, produced larger leaf number and leaf area and thus has more ample reserves of carbohydrates in the stubble [7]. In our study, this effect was in some cases seen when the data was divided firstly according to the tiller type of primary growth (in the case of tall fescue, only VEG and GEN tillers were present in the primary growth in sufficient number) and secondly according to the SP stage.

In timothy, there were no clear differences along the increase of SP stage inside any tiller type group, but the total leaf length and the amount of senesced leaf tissue per tiller tended to be smaller, when the SP stage of primary growth ELONG tillers was increasing until SP stage 35 (Figures 1C and 1D). Even though the regrowth parameters of primary growth GEN tillers of timothy were usually the highest, SP stage 45 during the primary growth of timothy seemed to produce smaller and more slowly growing tillers than SP stages 52 or 56 (Fig. 1A-D). From primary growth GEN tiller group, SP stage 52 (generative, inflorescence starting to emerge from the flag leaf sheath) and from primary growth VEG and ELONG groups, the SP stages 25 (vegetative with 5 leaves) and 37 (elongating with 7 nodes) seemed to produce the fastest growing and largest tillers into the regrowth, respectively, but the differences were not significant due to the small number or tillers and high variation.

An increase in the SP stage inside the primary cut VEG tiller group might increase the growth rate and total tiller length in the regrowth of tall fescue, but reduce the same parameters inside the GEN tiller group, but the differences were not significant due to large variation (Fig. 1A and 1C). Increased SP stage did not affect leaf appearance rate (LAR) or leaf senescence in tall fescue (Fig. 1B and D). In tall fescue, the primary growth tiller type (VEG or GEN) did not affect the growth rate or LAR, but the primary growth GEN tiller type produced a smaller amount of total leaf tissue and senesced leaf per tiller in the regrowth (Figures 1C and 1D). For obtaining large and vital tillers into the regrowth of tall fescue, primary growth VEG tillers, especially SP 24 (vegetative with four leaves) were the most optimal (Fig. 1A and 1c). From more advanced primary growth tillers, SP 45 (early generative, inflorescence swollen inside the flag leaf) produced fast growing regrowth tillers, but not large tiller size (Fig. 1A-C).



Figures 1A, 1B, 1C and 1D. **The effect of developmental stage (according to Simon and Park, 1981) of the tiller in the primary growth (PG) on A) growth rate of total tiller height (mm ºCd^{-1}); B) leaf appearance rate (LARx100, leaves ºCd^{-1} tiller^{-1} x100); C) total leaf length per tiller (mm tiller^{-1}); D) senesced leaf length per tiller (mm tiller^{-1}) inside each tiller type of timothy (TIM) and tall fescue (TF). VEG = vegetative, ELONG = elongating vegetative, GEN = generative. Given values are averages of tillers during the – 8 weeks of regrowth for tillers produced by certain SP stages in PG tiller types; error bars show standard error of the mean (SEM); number of tillers (*n*) is given below the SP stage.**

In the primary growth ELONG tillers, advanced SP stages mean that tillers have more nodes and internodes in the true stem but the number of leaves to emerge has not been fixed. In the GEN tillers, advanced SP stages means higher dedication to flowering and seed formation along with the formation of true stem. The formation of highly fibrous tissue for the stem – or the formation of an inflorescence – is biologically a costly sink for the tiller, which means less photosynthetic products are channelled and accumulated as storage carbohydrates or proteins into the root system and stubble. Thus, the reduction in the regrowth potential for the aftermath cut of these more developed primary growth tillers is probably due to the scarcity of reserved carbohydrates that should be available for the initiation of regrowth right after the cut.

CONCLUSIONS

Tiller type and developmental stage during the primary growth affected strongly on the recovery potential after the cut and on growth habits of the regrowth tillers in the same plant of timothy and tall fescue.
Tiller type in the same plant was not a constant feature, and other factors determine the final type of the tiller in the regrowth.
For the formation of large and rapidly growing tillers into the regrowth, highly advanced elongating vegetative (timothy), early generative (in both species) or large vegetative (in tall fescue) primary growth tillers were the most optimal. Lower vegetative or more advanced generative developmental stages lead to lower growth rates and smaller amount of leaf tissue per regrowth tiller, which is probably due the level and sufficiency of photosynthesized carbohydrates during the time of the primary growth cut.

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ENVIRONMENTAL IMPACT ON WINTER SURVIAL AND PRODUCTION IN NON-NATIVE GRASSES IN THE NORDIC COUNTRIES

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Abstract. *Cultivars of perennial ryegrass, hybrid ryegrass, Festulolium of different species combinations, and tall fescue were compared with the main local cultivar of meadow fescue in field trials in the five Nordic countries during the first two ley years. Accumulated dry matter yield (DMY) of the summer cuts varied from 24.8 t ha^{-1} (Denmark) to 12.8 t ha^{-1} (Iceland). Averaged over years and sites tetraploid perennial ryegrass (20.5 t ha^{-1}) yielded significantly more than meadow fescue (16.9 t ha^{-1}), the latter being the lowest yielding species group. Generally, tall fescue had higher production capacity than meadow fescue, and more attention should be paid to it in most regions. Total DMY in the late fall when grass growth had ceased was significantly lower in the winter hardy species tall fescue and meadow fescue than in the cultivars of ryegrass and Festulolium. The estimated winter damage was lower in Denmark and Sweden compared to the other sites. Large differences in winter damage within species groups were observed due to different inherent adaptability of the cultivars, especially within loloid Festulolium. Normalized difference vegetation index (NDVI) was measured as a proxy for growth cessation on the field plots in Iceland and Norway. Higher NDVI values were obtained in Norway compared to Iceland, however, with the same order of decreasing values for the investigated cultivars during the autumn period. The different climatic conditions in the Nordic region were clearly reflected in significant genotype x environment interactions which underlines the necessity of regional testing of cultivars for optimal production. Further breeding of the non-native grasses for the northern and inland part of the region is needed, employing selection of plants with decreased growth during autumn to secure better hardening and winter survival.*

Key words: *autumn growth, Festulolium, growth cessation, NDVI, perennial ryegrass.*

INTRODUCTION

In the Nordic countries major parts of the agricultural land is used for forage production, which is supporting the economically important forage based milk and livestock production [1]. The dominating forage crops are perennial grasses and legumes. Forecasted climate change constitutes a great challenge for perennial plants for which improved adapted and high yielding cultivars with good quality and disease resistance are key elements for securing sustainable agriculture in the Nordic region. Non-native species like perennial ryegrass (*Lolium perenne* L.) and Festulolium (×*Festulolium* Aschers. et Graebn.) are of increased interest for the future, with its expected longer growing season [2], because of their high production capacity throughout the growing season as well as high nutritive value. These species have, however, an inadequate autumnal growth cessation for sufficient cold acclimation [3]. Such a trait is though a prerequisite for persistent cultivars of these species in order to increasing their growing area in the Nordic region. The aim of this investigation was to study the adaptedness of commercial cultivars of perennial ryegrass, hybrid ryegrass (*Lolium* ×boucheanum Kunth) and Festulolium of different ploidy level and parental origin, compared with the more persistent species of the *Festuca* genera, when grown under different climatic conditions in the five Nordic countries.

MATERIALS AND METHODS

Field sites, design and measurements

Field trials were established in 2011 in Denmark (DK), Finland (FI), Iceland (IS) and Norway (NO) and in 2012 in Sweden (SE). Geographic coordinates and climatic data for the locations are described in Table 1. Field trials were established to assess winter survival and seasonal production, including a last cut after growth had ceased in the autumn. The field trials had three (FI, IS, NO) or two replicates (SE, DK) with a plot size of approx. 13.5m^2. In the late autumn, 3 m^2 of the main plot was harvested as an autumn cut, and this plot part was excluded from registrations and harvests the following year. Winter damage was calculated according to the formula (((previous fall ground cover – spring ground cover)/previous fall ground cover)*100). Herbage samples were dried at 60°C for 48 h and dry matter yield was estimated. In the ley year the trials were fertilised according to local norms, in total 320 (DK), 240 (FI), 150 (IS), 295 (NO), and 240 (SE) kg Nitrogen ha^{-1} year^{-1}. Results for the two first ley years are presented.

Plant materials

Tested cultivars (cv.) included perennial ryegrass, hybrid ryegrass, Festulolium and tall fescue (*Festuca arundinacea* Schreb), and these were compared with the main local cultivar of meadow fescue (*F. pratensis* Huds.) in each country/region (Table 3). The Festulolium cvs. belonged to festucoid (cv. Hykor) and loloid festulolium, of which the latter originates from the species combinations *L. multiflorum* x *F. pratensis* (cvs. Felopa, Hostyn, Paulita, Perseus and Perun) and *L. perenne* x *F. pratensis* (cv. Fabel). The cultivars were grouped into species groups according to species, parental origin and ploidy (Table 2).

NDVI. Ground-based NDVI (Normalized difference vegetation index) was measured on the field plots around midday during autumn 2012 (IS) and 2014 (NO), both places using a handheld SKR 1800 Two channel Light Sensor (Skye Instruments, Llandrindod Wells, UK) 2 m above ground level. NDVI is calculated based on the reflectance in the near infrared (NIR 780-900 nm) and red (660 nm) wavebands using the formula: NDVI = (NIR – Red)/NIR + Red). Values range between 0 and 1 for vegetated surfaces with high positive values indicating an abundance of photosynthetically active vegetation [4].

Statistical analyses

The data were analysed as a factorial design using the general linear procedure SAS PROC GLM [5] for dry matter yield, winter damage and NDVI index. Simple (Pearson) correlation coefficient analysis was carried out using PROC CORR [5] between NDVI, autumn cut and winter damage. AMMI (Additive Main effects and Multiplicative Interaction) analysis was performed using the R package Agricolae (http://cran.r-project.org/web/packages/agricolae/)

RESULTS AND DISCUSSION

Dry matter yield (DMY) during summer

Total DMY for the summer cuts during two ley years was significantly different between countries; 24.8 t ha^{-1} (SE), 23.3 t ha^{-1} (DK), 20.0 t ha^{-1} (NO), 17.6 t ha^{-1} (FI), and 12.8 t ha^{-1} (IS). Generally the DMY reflected the climatic conditions at the different sites (Table 1), and the lower DMY in Iceland is a combined response of shorter growing season and two annual cuts compared to three cuts elsewhere. Between species groups, tetraploid perennial ryegrass yielded significantly more than meadow fescue (Table 2). The first ley year was significantly higher yielding (10.7 t ha^{-1}) than the second ley year (8.59 t ha^{-1}) when averaged over all sites. The yielding capacity of the species groups at each site is shown in Table 3. Tetraploid perennial ryegrass yielded more than the other groups at all sites except in Iceland. Hybrid ryegrass performed well at the southern sites (DK, SE) but was sensitive to colder and longer winter conditions. Festulolium cv. Hykor was higher yielding than tall fescue in DK, NO and SE, and lower or equal in FI and IS, whereas the production capacity in the loloid Festulolium cvs. was higher than for perennial ryegrasses at the southern sites. In IS some of the loloid Festulolium cvs. suffered severe winter damage and gave no harvestable yield.

Table 1

Geographic location, temperature (°C) and precipitation (mm), length of the growing season (T>5 °C) and accumulated Day Degrees (° D; Tsum>5 °C) for the experimental sites as mean for the two first ley years.

Site	Latitude	Longitude	Temperature (°C)	Precipitation (mm)	Growing season (>5°C)	
					No. of growth days	°D
Bredeløkke (DK)	55°N	12°E	8.5	483	258	1990
Rådde, Länghem (SE)	58°N	13°E	7.0	1799	189	1454
Fureneset (NO)	61°N	18°E	7.3	2349	235	1322
Jokioinen (FI)	61 °N	24 °E	5.0	670	178	1409
Korpa (IS)	64°N	22°W	5.2	1183	178	733

Dry matter yield (DMY) in late fall

Total DMY in late fall for the two years differed significantly between countries (DK > FI > SE, IS > NO). Within the species groups, tall fescue and meadow fescue yielded significantly less than the remaining groups (Table 2). There were no significant differences between the two ley years.

Table 2

Total dry matter yield (DMY) of three cuts (two cuts in IS) during two years (total DMY) and of the autumn cut in cultivars of perennial ryegrass, hybrid ryegrass, groups of festulolium, tall fescue and meadow fescue. Ploidy level is indicated where appropriate (D = diploid, T = tetraploid).

Species	Ploidy	N	DMY, t ha^{-1}			N	DMY, t ha^{-1}		
			Total	SE			Autumn	SE	
Perennial ryegrass	T	65	20.50	0.57	a	60	2.19	0.20	a
Festulolium	T	70	19.48	0.72	ab	63	2.11	0.15	a
Perennial ryegrass	D	65	18.80	0.44	bc	60	2.10	0.20	a
Hybrid ryegrass	T	13	18.25	1.39	cd	12	2.08	0.43	a
Festulolium (Hykor)		13	17.89	2.01	cd	12	2.32	0.38	a
Tall fescue		13	18.28	1.48	cd	12	1.82	0.33	b
Meadow fescue		13	16.88	1.26	d	12	1.65	0.22	b

Different letters (a-d) within columns indicate significant differences between groups

Winter damage

In general the entries overwintered well at all sites the first winter, except at Korpa (IS) where the festucoid Festulolium (cv. Hykor) and some of the loloid Festulolium cvs. suffered badly. The second winter was also harsh in Finland and Norway except for the fescues and the festucoid Festulolium (cv. Hykor) which genetically is close to tall fescue. In spite of serious winter damage the plants were able to recover well in Norway (Table 3, Table 4).

G x E interactions

There were significant interactions (P<0.001) both for site × species group and site × cultivars thus reflecting different growing conditions in the Nordic region [1]. When low winter damage is experienced, as was the case both in DK and SE, the production capacity of perennial ryegrass and Festulolium outcompeted that of the fescues. Apart from in FI, tall fescue survived better and yielded more than the meadow fescue control indicating that it might receive increased interest in the whole region. In FI, tall fescue and Festulolium cv. Hykor established slowly and suffered from the late establishment date (5.8.2011) of the trial and this affected their DMY in the first cut in the first year. In IS the meadow fescue cv. Norild has traditionally been very persistent, however, more southerly adapted cultivars may prove to be more productive and still survive in a milder climate as is expected. This has been shown in a recent study across sites in the West Nordic region, where cv. Kasper did better than cv. Norild in IS [6].

Table 3

Total dry matter yield of three cuts (two cuts in IS) during two years (summer) and in the autumn cut (late fall) in cultivars of perennial ryegrass, hybrid ryegrass, festulolium (FL), tall fescue and meadow fescue. Ploidy level is indicated where appropriate (D = diploid, T = tetraploid).

Species group – ploidy (cultivars)		Total DMY summer, t ha^{-1}					Total DMY late fall, t ha^{-1}				
		DK	FI	IS	NO	SE	DK	FI	IS	NO	SE
Perennial ryegrass-D (Fagerlin, Indiana, Indicus, Picaro, Riikka)		22.1 (0.4)	17.8 (0.8)	15.0 (0.3)	18.4 (0.3)	23.4 (0.9)	4.99 (0.3)	2.41 (0.08)	1.26 (0.12)	0.85 (0.11)	1.22 (0.19)
Perennial ryegrass-T (Birger, Figgjo, Ivar, Jaran, Mathilde)		24.3 (0.6)	22.3 (1.0)	14.0 (0.4)	20.0 (0.4)	24.6 (0.6)	5.28 (0.19)	2.46 (0.08)	1.31 (0.12)	0.88 (0.07)	1.30 (0.09)
Hybrid ryegrass-T (Fenre)		24.0	15.9	11.7	19.6	23.7	5.01	2.41	1.14	0.88	1.24
FL (Hykor)		23.6	12.1	9.7	21.8	27.3	4.98	2.19	1.31	1.47	2.23
FL-T (Fabel, Felopa, Hostyn, Paulita, Perseus, Perun)		24.6 (0.5)	16.1 (0.7)	9.0 (1.3)	21.1 (0.2)	25.8 (0.3)	4.31 (0.18)	2.12 (0.07)	1.55 (0.22)	1.11 (0.09)	1.34 (0.05)
Tall fescue (Retu)		21.6	12.6	14.2	20.7	25.9	4.07	1.86	1.33	1.01	1.03
Meadow fescue	Laura	17.6					3.02				
	Kasper		15.8					1.93			
	Norild			10.9					1.17		
	Fure				18.5					0.83	
	Minto					24.5					1.38

Table 4

Winter damage (%) in first (wd1) and second (wd2) ley year for cultivars of perennial ryegrass, hybrid ryegrass, festulolium, tall fescue and meadow fescue. Ploidy level is indicated where appropriate (D = diploid, T = tetraploid).

	Denmark		Finland		Iceland		Norway		Sweden	
Species groups – ploidy	wd1	wd2	wd1	wd2	wd1	wd2	wd1	wd2	wd1	wd2
Perennial ryegrass-D	0	0	1	46	4	4	1	61	4	2
Perennial ryegrass-T	0	0	1	36	3	3	0	34	2	1
Hybrid ryegrass-T	0	0	2	43	4	3	0	59	2	2
Festulolium (Hykor)	0	0	3	8	37	35	0	1	1	1
Festulolium-T	0	0	6	90	72	73	0	40	1	2
Festulolium-T (Fabel)	0	0	0	37	0	0	1	38	2	1
Tall fescue	0	0	3	2	0	0	0	2	2	1
Meadow fescue	0	0	0	0	7	7	1	7	5	1

Stability analyses

AMMI phenotypic stability analysis of total DMY of cultivars (except meadow fescue) across environments (except Iceland) found that diploid perennial ryegrass cultivars are yielding lower than average, however, they are generally stable with cv. Rikka as the most unstable among them. In general, both tetraploid perennial ryegrass and Festulolium are stable and most are above average yielding, with cv. Jaran as the highest yielding of all and most unstable. Tall fescue cv. Retu is stable and above average yielding while cv. Hykor (Festulolium) is the most unstable cultivar of all with below average yields. Denmark (higher than average yielding environment) and Norway (lower than average yielding environment) display the most stable relative ranking of the cultivars, while Finland is a unique site which contribute most to the interaction.

Clear differences were observed for winter survival within the loloid Festulolium group probably because of their inherent adaptational level. Although the cultivars in this group have the same parental origin, when exposed to harsh climates some cultivars were more sensitive than others (cvs. Hostyn and Paulita). The better winter survival of the loloid cv. Fabel is in accordance with earlier studies in this region and confirms that when breeding loloid Festulolium for the northern parts of the Nordic region perennial ryegrass should be the preferred *Lolium* parent [7].

NDVI index

NDVI values from the field trials at Korpa (IS) and Fureneset (NO) are shown in Figure 1 for sampling dates during the autumn period. Higher NDVI values were observed in NO than in IS throughout the experimental period. At the end of September the NDVI values, averaged over all entries, were 0.91 (NO) and 0.86 (IS), and corresponding NDVI values at the end of November were 0.82 (NO) and 0.78 (IS). The *trend* was similar at the two sites and the variation between the highest and lowest NDVI index was wider in IS mainly because of the low values for the meadow fescue cultivar. At both locations lowest values were observed for the meadow fescue cultivar of all investigated cultivars. However, in IS the NDVI value fell much more rapidly for cv. Norild, a northerly adapted cultivar, than for the more southerly adapted cv. Fure at the Norwegian site. The adaptational level used here is referring to the Nordic region.
The NDVI index fell progressively throughout the experimental period. However, the NDVI index is very sensitive to temperature [8], and the generally mild autumn of 2014 at Fureneset (NO) probably affected the development at this site. The discrimination of the cultivars thus only became clear in the very late fall. This is opposite to Korpa (IS) where cultivars differed significantly already from early sampling dates [8].

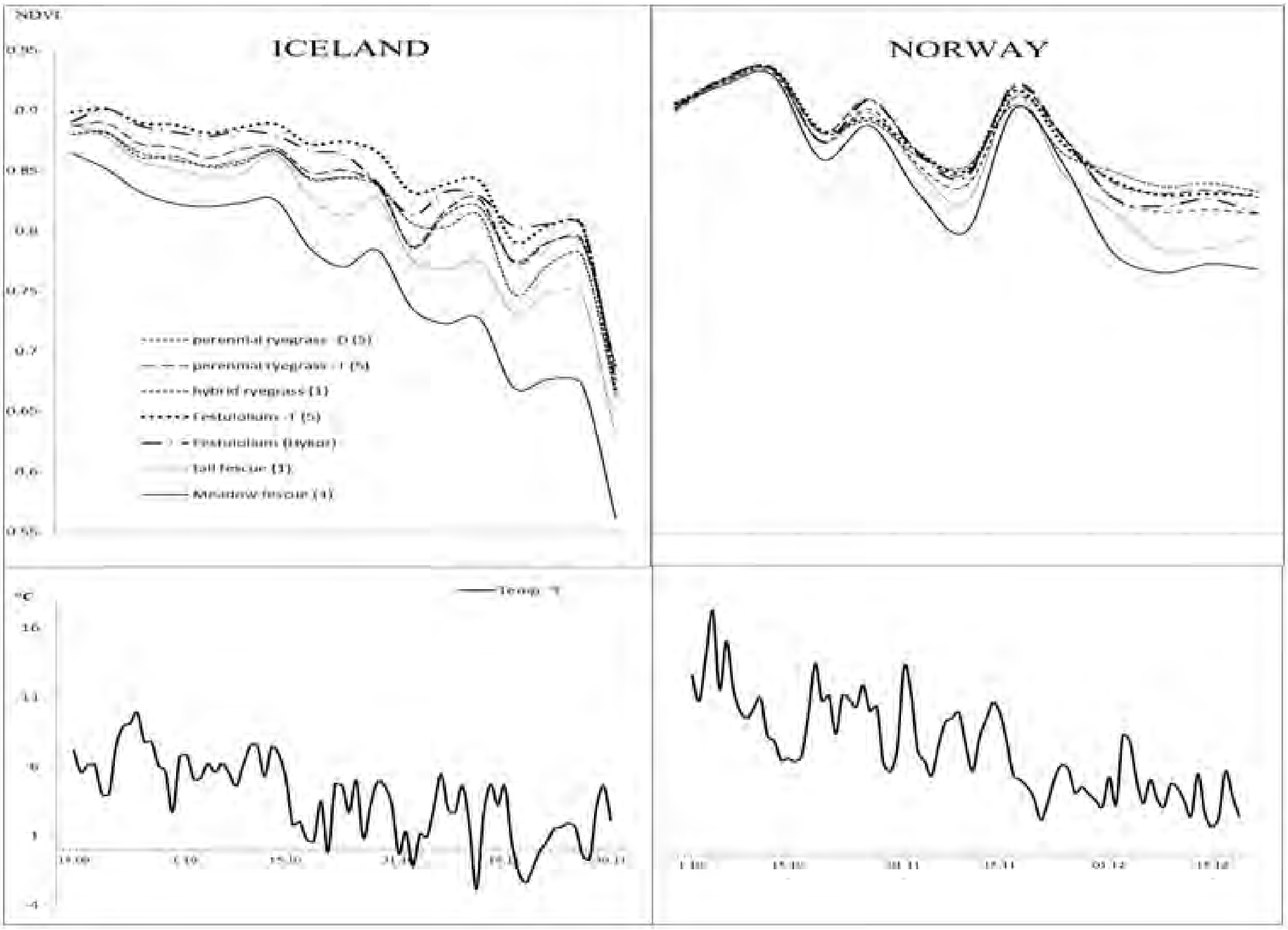

Figure 1. **NDVI values of different species groups in Iceland (2012) and Norway (2014) for 17 and 13 sampling dates, respectively, together with the daily mean temperature during the experimental period. No. of entries included in brackets for each species group. Ploidy level is indicated where appropriate (D = diploid, T = tetraploid).**

Simple correlations between autumn cut, NDVI and winter damage

No significant correlations were found between autumn cut (DMY) and winter damage the following spring, or between NDVI values and winter damage when averaged over all sampling dates or sites. Tall fescue and meadow fescue both yielded less than the remaining cultivars in the autumn cut, and the observed winter damage averaged for all sites was lower than the remaining cultivars. The low photosynthetic activity in late fall in the fescues was also confirmed in the obtained NDVI index. The two NDVI studies were, however, carried out in different ley years; during the first (NDVI) and second (winter damage) ley years in IS and both observations in the third ley year in NO. Generally the discrimination of winter damage between cultivars of the investigated species is not fully experienced until in the third ley year, and the decrease in persistence of plants was higher in NO than in IS.

In summary, the production capacity of the investigated species and cultivars is adequate for the first and second ley years being used in the regions where this study was carried out. Precautions should be taken to secure optimal establishment when grown in the margins of the growing area, including early sowing as well as avoiding flat areas that might be prone for water saturated periods and possible ice cover [6].

To extend the growing area further north and inland as well as for longer term leys, the breeding programs of non-native species have to consider the ability of proper growth cessation for sufficient hardening. Growth cessation is a prerequisite for proper hardening, and with higher temperatures as is already experienced during autumn in this region, the onset of acclimation will start later in the autumn at lower radiation and thus less optimal conditions. Growth cessation should be controlled by photoperiod rather than temperature while also maintaining a certain level of photosynthetic activity to secure the necessary carbohydrate status for survival [3]. Future grass breeding programs need to select genotypes with such traits.

CONCLUSIONS

The northern and inland parts of the Nordic countries are in a critical zone for growth of perennial ryegrass and festulolium. When winter damage is limited the production capacity in the non-native species is higher than in the fescues, and regional testing of cultivars is required to find the most optimal cultivars for persistence and production. Tall fescue may have increased interest in most regions.

ACKNOWLEDGEMENTS

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PERSISTENCE AND ESTABLISHMENT OF RED CLOVER UNDER EXTENSIVE FORAGE PRODUCTION SYSTEMS IN NORWAY

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Abstract. *Longevity and establishment of red clover in grassland was examined in field studies in Nordland County and in experiments at Tjøtta and Løken in Norway. Red clover plants in old swards showed very high age and a branched root system. Only a few seedlings were found suggesting that self-seeding was insignificant. Experiments with leaving the grassland after the first cut for seed production of clover failed due to poor seed produc tion. Surface seeding of red clover in pure grass plots gave good results, especially with early spring seeding.*

Key words: *clover age, longevity, self-seeding, surface seeding, sward.*

INTRODUCTION

The amount of clover in the field is decisive for the N_2 fixation, the protein content and general quality of the forage produced. One of the major problems in maintaining a desired content of clover in grassland is the seasonal and annual variation in performance. Red clover (*Trifolium pratense* L.) is normally a short-lived perennial with no vegetative propagation. The number of plants in the field normally declines rapidly. Lunnan (2004) found a decline from 60-90 plants m^{-2} in the autumn the year after sowing to 30-50 plants m^{-2} in the fourth production year with a corresponding decline in clover proportion of the stand and N_2 fixation.
In mainly grass producing areas most farmers prefer to have long-lasting grassland, while the costs and labour demand with a frequent renewal are high. In Japan, Sakanoue (2002) reported that a red clover stand has persisted for 20 years since its establishment under regular cutting at an altitude of 1200 m. The ability of legumes to regenerate from the soil seed bank has been also observed in Australia and the USA (Carr et al., 2005). These observations suggest that red clover might be maintained by self-seeding over time. However, most of the red clover seeds do not germinate immediately after falling to the ground. A large proportion of hard seeds germinate in the following spring leading to sufficient amount of clover in the subsequent year (Sakanoue, 2002).
Reseeding of clover in grass-dominated turf has been done with variable success in Norwegian experiments (Rivedal et al., 2001; Volden et al., 2005). One other option is to try self-seeding where red clover plants are allowed to set seed and thus renewing clover plants in the sward. This has not been tried in Norwegian experiments. After seed shattering the crop must be removed, and the sward should be kept short with grazing the following spring with no N fertilisation to reduce competition for clover seedlings.
In Nordland County there is a farm with a fairly good clover stand in more than 15 years old grassland. In the presented study we examined grassland botanical content and attempted to recognise age of red clover plants. Our hypotheses was 1) that extensive grassland management promotes self-seeding of red clover 2) self-seeding maintaining a desired content of red clover over time. In addition, we tested two harvesting regimes of the first cut for seed maturation and seed quality at two locations in Norway.

MATERIALS AND METHODS

Farm study

This study was carried out at the Handnesøya in Nordland County (66.27°N). The farm has been managed organically for 20 years. Plenty of grassland area allows extensive management, one cut during the growing season. The growing conditions are typical for coastal climate. Closeness to Polar Circle results in 24 hours light during summer and compensates low air temperatures during growing season. Winters are unstable with shallow snow cover and several freezing and thawing events. We chose to map 3- and 20-years old swards in early spring 2011. We assessed clover age and its content in sward. Age of red clover was evaluated randomly by digging up red clover plants and by assessing their root system. The roots of more than 30 red clover plants were dug up in each of sward and part of them was carefully washed under tap water. Botanical composition of the sward and the content of red clover was determined by the dry-weight range method (t'Manntetje and Haydock 1963).

Field studies

Red clover cv Bjursele (2x), Betty (4x) and Lea (2x) were sown in mixture with timothy (*Phleum pratense* L.) and meadow fescue (*Festuca pratensis* L.; 6 kg ha^{-1} red clover + 7 kg ha^{-1} timothy + 3 kg ha^{-1} meadow fescue) at two sites in Norway – Løken (530 m a.s.l., 61.12° N) and Tjøtta (10 m a.s.l., 65.49°N). The first cut was carried out at two different points of time: early heading of timothy and ten days later. In order to allow seed ripening about one third of the plot containing cv Bjursele was not harvested under the second cut. The forage yield was recorded under the both cuts. At Løken, forage quality was analysed. In late autumn, non-harvested red clover plants were cut and placed on the surface of pure grass plots (1 m^2 each). The establishment of red clover after different cutting regimes was recorded year after and compared with following surface seeding treatments: either 0, 2 and 10 kg ha^{-1} surface seeding in late autumn or early spring in pure grass plots. In addition, red clover seeds of cv Bjursele after different cutting regimes were collected in late autumn and tested for germination. Seeds were placed on wet filter in plates of Petri for one week at 18 °C. Thereafter number of germinated seeds was counted and germination capacity determined. All treatments described above had three replicates. Statistical analysis of ANOVA was performed to find out the effect of treatment.

RESULTS

Farm study

Assessment of botanical composition showed that timothy and meadow fescue dominated both in 3 and in 20 years old swards (Fig.1). The content of red clover in the old sward was moderate, on average 4%. In the three years old sward red clover content was significantly higher than in the old sward and was on average 27%.

Red clover plants from the young sward had a taproot, major part of roots were white and little branched (Fig.2). In contrast, the plants from the old sward had brown, dark brown and a branched root system (Fig.3 and 4). Those plants had no taproot and observations suggested that plants relied on lateral roots. Thus, red clover plants in old swards showed very high age. A proportion of young red clover plants was low (Fig.5). Very few seedlings of red clover were found in the 20 years old sward suggesting that self-seeding was insignificant.

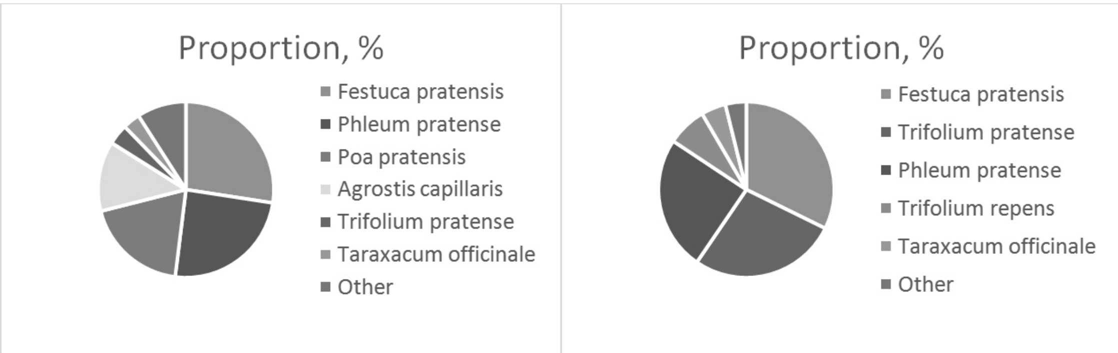

Figure 1. **Botanical composition in a 20 yr old grassland (left) and three year old grassland (right) at Handnesøya, Nordland County.**

Establishment of red clover

The content of red clover in the herbage varied between 30-70% at both experimental sites and years. Forage yields and quality of different cutting times at the first harvest are shown in Table 1. There were no difference in yield between red clover varieties, locations and years. However, cv Bjursele gave somewhat lower herbage yield than Betty and Lea in the second production year at Tjøtta. On average for both locations, uncut red clover after the first harvest resulted in 3.25 tons DM per ha loss of forage yield.

Figure 2. **A taproot of 3 years old red clover plant**

Figure 3. **A branched root system of more than 10 years old red clover plant**

Figure 4. **Red clover plants from 20 years old sward**

Figure 5. **Red clover seedling found in 20 years old sward**

Table 1

Yield, tons DM per ha, energy value, fodder units per kg DM and protein content (% of DM) in clover-rich grassland at two harvest times for the first cut. Average of three red clover cultivars and two fields

	Yield, t DM ha^{-1}		**Energy value, FU kg^{-1} DM**		**Crude protein, % of DM**	
Cut no	1	2	1	2	1	2
Early 1st cut	4.35	3.65	0.91	0.83	14.6	16.7
Medium 1st cut	6.00	2.85	0.81	0.87	14.5	17.3

About 90% of red clover plants flowered at both sites and experimental years. However, cold and rainy second part of summer limited seed development and maturing, particularly at the first experimental year at Løken when there were no mature seeds at all (Table 2). Red clover seeds collected at Tjøtta showed better germination capacity at the first production year than at the second production year.

Surface seeding in established pure grass stand gave better results than placement of cut red clover donor plants (Table 3). The surface seeding in early spring showed better result of red clover establishment than the surface seeding in late autumn.

Table 2

Germination rate (%) of red clover seeds collected late autumn after early and medium harvest time in the first cut at Tjøtta and Løken

	Early 1st cut	Medium 1st cut
Tjøtta 2012	43	12
Tjøtta 2013	9	13
Løken 2012	0	0
Løken 2013	25	17

Table 3

Number of established red clover plants per m^2 in pure grass stands at Løken and Tjøtta

	Red clover plants, n m^{-2}		
	Løken, autumn 2013	**Løken, summer 2014**	**Tjøtta, autumn 2013**
Grass control	0	1	0
Donor after early 1st cut	2	4	0
Donor after medium 1st cut	1	0	0
Autumn seed, 2 kg ha^{-1}	14	5	3
Autumn seed, 10 kg ha^{-1}	67	41	24
Spring seed, 2 kg ha^{-1}	90	67	17
Spring seed, 10 kg ha^{-1}	309	213	49
SE mean	6.6	13.0	6.7
P value	<0.001	<0.001	0.001

DISCUSSION

Usually, there are very few red clover plants in old swards. Common harvesting systems in Norway do not promote seed development and self-seeding in older grasslands. Thus, red clover content and density decrease with time. Moreover, thick layer of dead plant material in old sward may limit establishment of seedlings. Mapping of red clover at Handnesøya suggests that renewal of red clover by self-seeding was low in swards up to 20 years age. Sometimes red clover seeds do not germinate immediately after falling to the ground. A large proportion of hard seeds might germinate after some period leading to sufficient amount of clover in the subsequent years (Sakanoue, 2002). In our study, the majority of red clover plants were old with branched root system. This finding suggests that extensive harvesting system with one cut during the growing season and long regrowth period after may preserve red clover plants rather well. However, we were not able to find out exact age of the plants but the root system suggested that red clover plants were old.

Experiments with red clover for self-seeding showed that the growing period and weather conditions after the first cut were unsatisfactory for seed ripening at both Løken and Tjøtta. In such weather conditions, seed development probably would be more successful without cutting. The yield loss without cutting usually will have higher economical value for the farmer than buying seeds for reseeding. This self-seeding method therefore only might be interesting for farmers with a surplus of grassland area compared to the forage need. In practical farming, seed could be produced in stripes while the rest of the area is harvested in normal time for forage. The seed crop then can be spread over the total area after cutting.

Field experiments showed that surface seeding in spring gave the best results. Thus, winter damages might be repaired by spring reseeding in young swards. Our experiments also showed that red clover seeds germinate well without any soil tillage. However, in old swards some restrictions may occur. The seed contact with soil surface may be limited and decomposing plant material may affect seed germination (Haugland and Brandsæter 1999). Under such conditions, some soil tillage must be applied. In practise, the clover plants are small in the seeding year and have small impact on forage yield and quality. The effect of clover increases in the next production year.

CONCLUSIONS

This study shows that in northern climate, growing season is too short for qualitative red clover seed production after the first cut. Thus, self-seeding of red clover would be rare in extensive managed grasslands. Assessment of red clover plants in old swards showed that clover might have a very long lifespan if only one cut applied during the growing season. Old red clover plants lived on branched lateral root system as the taproot had died away. Spring surface sowing of red clover might work well in young grass swards.

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PRODUCTIVITY OF CROPS OF FIELD ROTATION IN CONTRASTING GROWING SEASONS

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Abstract. *Given the need for sustainable intensification of crop production, experimental assessment of factors contributing to yield variability and uncertainties in nutrient balances in a field crop rotation is essential. The study, aimed at performance of crops under different management in relation to weather conditions, was conducted during 2008-2011 at the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry in Dotnuva, Kėdainiai, Central Lithuania. The soil is characterised as sandy loam, neutral, medium in available potassium and phosphorus. Crop rotation: winter wheat, spring rape, spring barley and red clover were replicated in time. Crops were grown without or with fertilizers and plant protection measures designed for target yield (7; 2.5 and 5 t ha^{-1} for winter wheat, spring rape and barley respectively). Treatments were replicated twice in space; each experimental plot occupied approximately 790 m^2 and contained 6 sub-plots 44 m^2 in size.*

The crop growth period during the experimental years was significantly warmer than the climate normal and with contrasting rainfall. Although modelling indicated temporal water stress in all experimental years, significant yield losses occurred only in a few cases. A drought in the summer 2008 resulted in a low spring rape seed yield and poor establishment of red clover undersown in spring barley, thus the field was ploughed and peas where sown in 2009. The outcome is an increase in nitrate concentrations in drainage water in winter-spring season of 2008-2009 and reduction of yield of winter wheat, which followed peas, in 2010. Heavy rains in late July 2011 resulted in severe lodging of winter wheat grown under conventional management, which substantially contributed to increased year-to-year variation of yield. On average, yield of winter wheat grown without fertilizers and pesticides was 67%, spring barley 70%, spring rape 47% and red clover 124% of that under conventional management. Protein content in winter wheat and spring barley grain was enhanced under conventional management; however, oil content in spring rape seeds was reduced.

Key words: *yield, protein, management, drought.*

THE EFFECT OF *RHIZOBIUM LEGUMINOSARUM* STRAIN GENOTYPE ON HOST PLANT PHENOTYPIC EXPRESSION

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Abstract. *The use of legumes, a wholesome source of protein, in commercial agriculture is increasing rapidly throughout the world. Legume crop yield is highly influenced by the symbiotic relationships with nitrogen fixating bacteria – rhizobia that supply plants with the necessary amount of nitrogen. This symbiotic relationship is beneficial also for the next crops, as the soil is enriched with nitrogen, thus limiting the use of chemical fertilizers. Legume use in agriculture is based on efficient rhizobia activity, therefore research on rhizobia is of great importance. In this study we focus particularly on Rhizobium leguminosarum. There are 13 different R. leguminosarum strains in the collection of Latvia University of Agriculture. These strains have shown different nitrogen fixating activity as well as different effect on host plant growth. Previous studies have observed existence of genotypic differences between R. leguminosarum strains. For successful R. leguminosarum use in agriculture, it is important to assess the genetic impact on the crop production. To fully identify these R. leguminosarum strains, it is necessary to use molecular biology methods in order to find out the genetic differences between the strains. Depending on the chosen R. leguminosarum strain, host plant phenotypic characteristics can change; also plant biochemical content (i.e., protein content) can be altered. The efficiency in some R. leguminosarum strains can be explained by genetic differences between strains, as well as plant and microorganism genetic interaction. Differences in R. leguminosarum strain activity and efficiency, explained by genetic differences between the strains, open new opportunities for the rhizobium use in agriculture. This project is supported by EU 7th frame EUROLEGUME project (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed).*

Key words: *rhizobia, legumes, crop yield, identification of R. leguminosarum.*

THE EVALUATION OF PERENNIAL GRASS CULTIVARS IN LATVIA CONDITION

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Abstract. *In order to evaluate the species and breeds of perennial grasses from the neighbouring countries and to determine more persistent and productive cultivars suitable for growing in Latvia conditions 29 cultivars from 4 countries (LT, LV, EE, SE): 6 cultivars of Lolium perenne (Lp), 3 Festulolium (FxL), 7 Phleum pratense (Pp), 7 Festuca pratensis (Fp), and 6 Dactylis glomerata (Dg) were studied by using randomized complete block design with three replications. Such characteristics as forage dry matter yield (DMY), winter hardiness, regrowth intensity of all cultivars were measured during the 5 years of use and fodder quality of Lp, FxL and Fp cultivars was determined in the 1st and 2nd cut. The results indicated that Pp, Fp and Dg cultivars were characterized by long and more stable persistence in sward in Latvia conditions. In the 5th year of use Lp cultivars disappeared greatly from the sward after black frost. Higher and more stable yields over the 5 years of use accounted for Pp cultivars; the best ones: 'Switch' (SE), 'Varis' (LV), 'Teicis' (LV) provided more than 7 t ha^{-1} DMY on average. During the 4 year period FxL cultivars provided good average DMY with high forage quality.*

Key words: *perennial grasses, cultivars, dry matter yield, forage quality, winter hardiness.*

INTRODUCTION

Perennial grasses (*Phleum pratense L.*, *Festuca pratensis Huds.*, *Dactylis glomerata L.*, *Lolium perenne L.*, *Festulolium)* are the main components of permanent grasslands in sustainable grassland ecosystems throughout the temperate climate zones. In many countries an active breeding work is carried out with the aim to create new cultivars with prolonged existence in sward, increased productivity and improved fodder quality. A very important property of perennial grasses is their ability to give stable and high dry matter yields under different environmental conditions [13]. The level of the productivity and stability depends on the genetic potential of the forage grass species [4].

The most important forage grass species in the Nordic region to the north of 60^0 N is timothy. In Norway, Sweden and Finland, timothy is the only grass species that can be grown successfully almost anywhere because of its superior persistence [11],[15]. It constitutes the main species in most seed mixtures [12]. A hardy perennial bunchgrass, adapted to cool climates and frequently used in timothy based mixtures for combined cutting and grazing in Northern countries is Meadow fescue (*Festuca pratensis Huds*.). It is widely adapted to lowlands of central and northern Europe and appropriate for intensive management system [1].

Perennial ryegrass (*Lolium perenne L.*) (*Lp*) is the dominant forage grass species in Europe due to its high regrowth capacity, rapid establishment, tolerance to frequent cutting and high nutritive value for ruminant livestock [19]. *Lp* plays an important role in the more maritime regions southward the 60^0 N. In the southern parts of Sweden it is grown successfully, but there always in mixtures with other grasses as it is still too unreliable to be grown in monoculture [14]. With its superior properties *Lp* will undoubtedly become a promising option at higher latitudes with prolonged growing season and milder winters. Fescues (*Festuca* spp.) and ryegrasses (*Lolium* spp.) can be hybridized fairly easily [9], which makes it possible to combine the superior forage quality of ryegrass species with the high persistency and stress tolerance of fescues in interspecific *Lolium*×*Festuca* hybrids (×*Festulolium*) [15]. Festulolium hybrids have a great recombination potential, which is being successfully used in plant breeding [2],[17].

Orchardgrass (*Dactylis glomerata* L.) (*Dg*) starts growth early in spring, develops rapidly, and flowers during May under Latvia conditions. It is more tolerant of shade, drought, and heat than the timothy. *Dg* can be grown in poor and shallow soils [16] and to produce high yields within proper management.

In general grasslands are not only a relatively cheap source of feed for ruminants, but are also increasingly being recognized for their contribution to the conservation of biodiversity, to the regulation of physical and chemical fluxes in ecosystems, to the mitigation pollution and to production of landscape amenity [6].

The aim of our study was to compare various species and breeds of perennial grasses from the neighbouring countries and to determine more persistent and productive cultivars suitable for growing in Latvia conditions for qualitative fodder production.

MATERIALS AND METHODS

The comparison of varieties included 29 cultivars from 4 countries (*LT*, *LV*, *EE*, *SE*): 6 cultivars of *Lolium perenne* (*Lp*), 3 Festulolium (*FxL*), 7 *Phleum pratense (Pp), 7 Festuca pratensis (Fp),* and 6 *Dactylis glomerata (Dg)*. The trial was conducted at the experimental field of the Research Institute of Agriculture in Skriveri (56°37 N and 25°07 E) in a randomized block design with three replications. The number of standard was raised to the 12th in order to enhance the accuracy of the test. Accounting plot area 10 m^2. The trial was established in May 2009 without cover crop in a sod-podzolic loam soil, pH KCl 6.0, plant available $P_2O_5$132 mg kg^{-1}, K_2O 86.0 mg kg^{-1}, organic matter content 1.8 g kg^{-1}. Seeding rates: *Lp* 20; *Pp* 12; *Fp* 25; *Dg* 15 kg ha^{-1}. Basic fertilisation before sowing was not used; in the production years ammonium nitrate (60 N) was used 3 times per year: in early spring just after the beginning of vegetation and after the 1st and 2nd cut (in total 180 N per year). The first cut was done at heading; the aftermaths harvest times (2) were decided depending on the weather conditions in the growing season. The research was done until 2014, thereby for 5 years the dry matter yield (DMY), regrowth intensity comparing aftermath yield with total yield and winter hardiness of each breed were evaluated. For *Fp*, *Lp* and *FxL* forage quality was determined: N (Kjeldal method); ADF, NDF and ash (gravimetrical method and calculation). Crude protein (%) was calculated using coefficient (N,%*6.25_{coef}). Relative feed value (RFV) was calculated using formulas RFV = DDM*DMI/1.29_{coef}; DDM% =88.9_{coef} – (0.779_{coef}*ADF%); DMI% = 120_{coef}/NDF%.

Climatic conditions during the 2009-2014 in Latvia were very various both in winter and summer period, and they also differed sharply over the month. Lots of rainfall fell during the 1st growing season in 2010 (569 mm). Very different climatic conditions prevailed in 2011, when the growing season was dry and relatively warm, the plants lacked moisture from the early summer. Altogether in growing season there was 431 mm rainfall. In June and July there was hot weather with an average air temperature 17.8^0 and 20.2^0 respectively. The spring and beginning of summer 2012 was very cool and rainy, during the growing season there was 655 mm rainfall. The growing season of 2013 was characterized by very favourable growing conditions – long, warm, with sufficient precipitation. Especially extreme wintering conditions developed in winter 2013/2014, when in December the mean air temperature was +6…8^0 C over the long lasting average, therefore vegetation continued. On January 12 it began to freeze and frost increased in force every night reaching –24^0 in the 3rd decade. There was black frost with strong North-East winds until February 10. For all overwintering crops, including grasses, it was a big challenge. The following spring was early, but very cool and wet, while during the summer months – July and August there was a prolonged drought and heat.

Statistical analysis. 1. Significance of the differences ($P < 0.05$) among the cultivars was detected by data processing with Microsoft Excel program data subprogram using mathematical and statistical functions.

RESULTS AND DISCUSSION

The climate change and new types of stresses will have various implications for adapting forage cultivars to the changing conditions both through breeding and different management schemes [7]. Grassland productivity is affected by several factors: soil characteristic, climatic conditions – particularly total and seasonal distribution of rainfall and temperature – altitude, latitude and management [6]. Different climatic conditions during testing years influenced growing and development as well as dry matter yield (DMY) of cultivars, therefore the yield varies considerably for all grass species over the years. It is especially expressed in 2011 when DMY are significantly lower due to cool and dry condition.

Productivity varies both between the species and cultivars. In Latvia agro-climatic conditions higher and more stable yields have been produced by *Phleum pratense* (*Pp*), *Dactylis glomerata* (*Dg*) and *Festulolium* (*FxL*) for several years (Table 1). The favourable growing season of 2010 contributed the development of grass, therefore despite rather low fertilisation level (without using of P and K) in the 1st year of use high DMY was obtained: over 9.0 t ha^{-1} for *FxL*; 7.74-9.43 t ha^{-1} for *Pp*; 5.83-6.49 t ha^{-1} for *Festuca pratensis* (*Fp*) and 5.83-6.49 t ha^{-1} for *Dg*.

Table 1

The evaluation of productivity (DMY) and winter hardiness (WH) of cultivars

Variety (origin)	DMY, t ha^{-1} (per year and on average 2010-2014)						Aftermath of DMY_{tot} 2010-2014, %	WH (1-9 p.) 2014
	2010	2011	2012	2013	2014	on average		
Dg Priekuļu 30 (LV) (a)	6.19	5.88	5.16	7.21	6.57	6.20^{bcd}	50.5^{D}	7.2^{Cd}
Dg Jõgeva 242 (EE) (b)	5.66	5.37	4.97	6.90	6.06	5.79^{A}	50.7^{D}	7.0^{Cd}
Dg Jõgeva 220 (EE) (c)	5.48	4.98-	5.29	6.22-	6.36	5.67^{A}	50.2^{D}	8.3^{abdef}
Dg SW Luxor (SE) (d)	5.33	4.48-	4.90	5.99-	6.19	5.37^{AEF}	57.3^{abcef}	6.0^{ABCEF}
Dg Regenta (LT) (e)	6.30	5.76	5.13	6.89	5.79	5.97^{d}	51.5^{D}	7.0^{Cd}
Dg Aukštuolė (LT) (f)	6.13	6.15	4.94	6.72	6.13	6.01^{d}	48.3^{D}	7.0^{Cd}
$LSD1_{0.05}$	*1.02*	*0.82*	*0.70*	*0.96*	*0.87*	*0.37*	*2.79*	*0.66*
$LSD2_{0.05}$	*1.25*	*1.00*	*0.86*	*1.24*	*0.78*	*0.46*	*3.42*	*0.81*
Fp Silva (LV) (a)	6.49	4.63	5.00	6.18	3.11	5.08^{bcefg}	40.4^{De}	6.9
Fp SW Minto (SE) (b)	5.83-	3.66-	4.07-	5.10-	2.53-	4.42^{AD}	43.0^{Defg}	7.0
Fp Patra (LV) (c) 4n	5.71-	4.13	4.76	5.32-	2.51-	4.49^{AD}	40.5^{De}	6.7
Fp Kaita DS (LT) (d)	5.98	4.81	4.99	5.94	2.71-	4.89^{bce}	57.3^{abcefg}	6.7
Fp Raskila (LT) (e) 4n	6.02	4.58	4.42	4.93-	2.30-	4.45^{AD}	35.8^{ABCD}	7.0
Fp Arni (EE) (f)	6.29	4.52	4.14-	5.37-	2.95	4.65^{A}	37.8^{BD}	7.0
Fp Vaira (LV) (g)	6.27	4.16	4.56	6.28	2.58-	4.77^{A}	38.4^{BD}	6.7
$LSD1_{0.05}$	*0.61*	*0.59*	*0.67*	*0.55*	*0.32*	*0.25*	*3.29*	*0.85*
$LSD2_{0.05}$	*0.79*	*0.76*	*0.86*	*0.71*	*0.41*	*0.33*	*4.25*	*1.10*
Pp Teicis (LV) (a)	8.20	6.68	7.81	8.28	4.77	7.15^{BE}	33.4^{BCDE}	6.7^{B}
Pp Switch (SE) (b)	9.43+	6.66	8.90+	7.66	5.21	7.57^{adfg}	41.1^{acdfg}	7.7^{aef}
Pp Varis (LV) (c)	7.82	6.59	7.98	8.30	5.43	7.22^{E}	37.1^{aBEfg}	7.0^{e}
Pp Jauniai (LT) (d)	7.74	6.55	7.11	7.02-	5.18	6.72^{BE}	35.6^{aBEfg}	7.0^{e}
Pp 2690 (LT) (e)	8.78	5.92	9.38+	9.33+	6.92+	8.07^{acdfg}	41.1^{acdfg}	6.0^{BCDG}
Pp Jõgeva 54 (EE) (f)	8.18	6.82	7.72	7.24-	4.33	6.86^{BE}	32.5^{BCDE}	6.7^{B}
Pp Tika (EE) (g)	8.23	6.31	7.72	7.48	4.69	6.89^{BE}	33.5^{BCDE}	7.0^{e}
$LSD1_{0.05}$	*0.90*	*0.87*	*1.01*	*0.85*	*0.94*	*0.40*	*1.67*	*0.65*
$LSD2_{0.05}$	*1.14*	*1.10*	*1.28*	*1.08*	*1.19*	*0.50*	*2.11*	*0.82*
Lp Spīdola (LV) (a) 4n	7.90	4.63	6.02	5.37	X	5.98^{f}	34.5^{CGHI}	2.0
Lp SW Birger (SE) (b) 4n	7.94	5.08	5.26	5.39	X	5.92^{f}	37.5^{C}	3.0
Lp Elena DS (LT) (c)	7.66	4.82	6.46	4.01-	X	5.74^{f}	45.9^{abdef}	1.0^{DEF}
Lp Raminta (LT) (d)	7.09	4.78	6.24	4.79	X	5.73^{f}	37.4^{C}	4.7 c
Lp Raite (EE) (e)	7.11	4.49	5.97	6.03	X	5.92^{f}	38.7^{C}	5.0 c
Lp Raidi (EE) (f)	6.32-	4.11-	4.88-	4.11-	X	4.86^{ABCDE}	32.4^{CGHI}	5.0 c
$LSD1_{0.05}$	*0.92*	*0.50*	*0.77*	*0.79*	*X*	0.38	*4.91*	*2.68*
$LSD2_{0.05}$	*1.13*	*0.61*	*0.94*	*0.97*	*X*	0.47	*6.01*	*3.28*
FxL Saikava (LV) (a) 4n	9.79	5.00	7.24	6.73	X	7.19	40.8^{af}	3.7
FxL Punia (LT) (b) 4n	10.20	5.67	6.62	6.84	X	7.33	40.3^{af}	4.0
FxL Vizule (LV) (c) 4n	9.40	5.27	6.22	6.33	X	6.81	42.2^{af}	3.7
$LSD1_{0.05}$	*1.66*	*0.90*	*1.11*	*1.02*	*X*	*0.60*	*6.01*	*3.05*

*$LSD1_{0.05}$ – variants have been compared with standard
**$LSD2_{0.05}$ – variants have been compared between themselves
(+);(-) – deviations from the standard
Letters: capital – indicate to the variant with significantly lower DMY;
lower-case – to significantly higher DMY(both compared with standard).

Very different growing conditions developed in 2011, from the beginning of vegetation up to July it was very dry, grasses lacked moisture, nitrogen fertiliser was not used effectively. Under such circumstances the highest DMY (over 6 t ha^{-1}) was developed by *Pp* varieties, whereas this species is less demanding in terms of soil and climatic conditions. Lower yield (less than 5 t ha^{-1}) accounted for more demanding species: *Lp* and *Fp* breeds, as *Lp* is demanding in nutrients, but *Fp* has an advantage in damp areas, therefore meadow fescue is commonly used in pasture mixtures in cool, moist environments [3].

The growing season of 2012 was different from the previous one with very rainy and cold spring and summertime. This affected grass growth and development regime, time of harvesting and DMY. The second half of summer was warm and dry, the resulting DMY of *Pp*, *FxL* and *Lp* in the 3rd year of use in general was satisfactory. The highest DMY (7.11-9.38 t ha^{-1}) was produced by *Pp* varieties: the best results accounted for No '2690' (LT) and 'Switch' (SE) – 9.38 t ha^{-1} and 8.90 t ha^{-1}, respectively. The lowest DMY in this condition accounted for *Dg* and *Fp* cultivars – on average it was within 4 to 5 t ha^{-1}.

In 2013 there developed favourable conditions for grass growth, it was warm and moist. Since it was the 4th year of sward use, the total DMY was considered to be good, more stable and higher DMY was provided by *Pp* (7.02-9.33 t ha^{-1}), *FxL* (6.33-6.73 t ha^{-1}) and *Dg* (above 6.0 t ha^{-1}) cultivars.

In the 5th year of use after black frost during winter 2013/2014 a lot of plants disappeared from *Lp* and *FxL* swards, therefore it was decided not to account the DMY for these species. However, such atypical wintering conditions didn't affect the sward quality of *Pp* and *Dg* cultivars, which provided the highest DMY: the best results was 6.57 t ha^{-1} for *Dg* 'Priekuļu 30' (LV) and 6.92 t ha^{-1} for *Pp* No '2690' (LT).

A significant role in the formation of high and stable DMY of perennial grasses is played by the availability of K and P nutrients. As the analysis of soil in trial field showed low K and medium P content and these plant nutrients were not provided with any fertiliser, it was a limiting factor, therefore DMY in general for all species were not very high, although harvest levels varied significantly between species and cultivars.

The trial data show that on average the lowest DMY in 5 years of use (< 5.0 t ha^{-1}) accounted for *Fp* under these circumstances, the most productive cultivar was 'Silva' (LV) – 5.08 t ha^{-1}. The data indicate that all *Fp* cultivars included in testing are of intensive type, especially 4n varieties are very demanding on fertiliser. The percentage of aftermath from total DMY for *Fp* cultivars ranged within 20% – from 37.8% 'Arni' (EE) to 57.3% 'Kaita' (LT), noting that the first one regrow more slowly compared with the second mentioned (Table 1). Assessing the winter hardiness (WH) of *Fp* cultivars in the spring of 2014 (5th year of use), it was found that all varieties have shown good WH, it ranged slightly – from 6.7 to 7.0 points (Table 1).

More productive of *Dg* varieties was standard 'Priekuļu 30' (LV) – providing 6.2 t ha^{-1} on average during the 5 years of use. This cultivar showed good WH, to (7.2 points). The greatest percentage of aftermath of total DMY was for cultivar 'Luxor' (SE) – 57.3%, which shows good regrowth capacity. In our trials 'Luxor' was evaluated as the latest-type cultivar in comparison with other included, while the earliest one was 'Jõgeva 220' (EE), which stood out with very good winter hardiness (8.3 points).

More stable and high yields under certain circumstances and management were provided by *Pp* breeds, most productive was perspective No '2690' (LT) – 8.06 t ha^{-1} on average in 5 year of use. The standard 'Teicis' (LV), which is early-type cultivar, produced 7.15 t ha^{-1}. The highest percentage of aftermath yield (41.1%) accounted for breeds: No '2690' (LT) and 'Switch' (SW). Timothy usually distinguished with good WH. In our trial after the 5th year wintering ratings for *Pp* varieties were satisfactory, ranging from 6.0 No '2690' (LT) to 7.7 points 'Switch' (SW).

Evaluating the DMY of *Lp* cultivars during 4-year period is seen that the results are quite similar (from 4.86 t ha^{-1} for 'Raidi' (EE) to 5.98 t ha^{-1} for 'Spīdola' (LV). A larger proportion of the grass aftermath (46%) and hence better regrowth ability were detected for cultivar 'Elena' (LT). WH in the period of 2010-2013 for all *Lp* varieties was good. A lot of *Lp* plants disappeared from sward after black frost during the winter of 2013/2014, but the results differed between cultivars. Lower WH was noticed for 'Elena' (LT), but Estonian cultivars 'Raite' and 'Raidi' stood out with better overwintering.

All three *FxL* cultivars were evaluated as quite similar, on average DMY in 4 years a slightly lower (6.81 t ha^{-1}) accounted for 'Vizule' (LV), higher (7.33 t ha^{-1}) for 'Punia' (LT), which stood out with better WH, too. Whereas the highest aftermath percentage (42.3%) of the total DMY and therefore the best regrowth abilities were shown by cultivar 'Vizule' (LV).

Forage quality. Harvesting and grazing management have to be dealt with the trade – off between forage quantity and quality to maximize net energy and protein harvested per ha. Feeding value of pasture is the product of voluntary feed consumption and the digestibility of nutrients consumed [10]. Nitrogen is a key factor in grassland farming and in ruminant nutrition [18].

Protein is often a limited resource on farms with high yielding dairy cows. The highest protein content of *Fp* cultivars in the 1st mowing are for: 'Arni' (EE) – 12.50% and 'Kaita' (LT) – 12.31%; in the 2nd mowing for: 'Patra' (LV) – 17.13% and 'Minto' (SE) – 17.12% (Table 2). The 2nd mowing forage quality is better, what can be explained by the fact that there in the sward are very few culms. A biomass is accumulating with plant growth, sward quality in terms of net energy, protein content and potential voluntary intake in decreasing as a result of plant maturation. A less mature plant contains a lower proportion of true stem and dead material and a greater proportion of leaf which is lower in fibre and highly digestible [5].

Table 2

Forage quality during period 2010- 2011 (in average)

Variety	Crude protein, %		Relative feed value RFV		Ash, %	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Fp Silva (LV) (a)	11.74	15.45	100.16^{H}	109.43	6.31	7.31
Fp SW Minto (SE) (b)	10.66	17.12^{i}	101.50^{dH}	108.13	6.12	7.14^{K}
Fp Patra (LV) (c) 4n	11.06	17.13^{i}	102.66^{dH}	114.41	5.79^{F}	7.49
Fp Kaita DS (LT) (d)	12.31	16.01	$89.49^{BCEFGHIK}$	109.69	5.46^{FK}	7.51
Fp Raskila (LT) (e) 4n	11.76	16.25	104.53^{dH}	113.93	5.73^{F}	6.97^{K}
Fp Arni (EE) (f)	12.50^{j}	15.39	104.49^{dH}	104.52	6.79^{cdeh}	7.00^{K}
Fp Vaira (LV) (g)	11.65	15.27	101.34^{dH}	101.28	6.00	7.19^{K}
Lp Spīdola (LV) (h) 4n	10.14	14.20	$121.42^{abcdefgijk}$	114.11	5.70^{F}	8.00
FxL Saikava (LV) (i) 4n	9.71	10.35^{BC}	104.14^{dH}	104.27	6.22	7.79
FxL Punia (LT) (j) 4n	8.56^{F}	13.35	99.37^{H}	103.05	6.14	8.08
FxL Vizule (LV) (k) 4n	8.96	12.58	107.6^{dH}	101.76	6.48^{d}	8.50^{befg}
$LSD1_{0.05}$	*3.44*	*6.00*	*10.40*	*15.24*	*0.86*	*1.12*

When comparing the forage quality of *FxL* with *Lp*, which is recognized as the most valuable perennial grass species in the world, we can see that no *FxL* cultivar exceeds *Lp* 'Spīdola' (LV) in protein content of the 1st mowing; in the 2nd mowing good performance in protein content is for *LxP* 'Punia' (LT) and 'Vizule' (LV).

Relative feed value (RFV) characterize the forage quality. If the index is above 100, the feed is assessed as good; above 124 – as very good; but if the index is less than 100 then feed is not enough quality. For our evaluated cultivars RFV ranged from 99.37 *FxL* 'Punia' (LT) to 121.42 *Lp* 'Spīdola' (LV) in the 1st cut and from 101.28 *FxL* 'Vizule' (LV) to 114.41 *Fp* 'Patra' (LV) in the 2nd cut. Both tetraploid (4n) *Fp* cultivars 'Patra' and 'Raskila' are distinguished by higher RFV, what is a characteristic feature of tetraploid *Fp* cultivars in general due to the chemical content of its swards.

The ash indicates the total mineral substances content in forage. Too much ash in forages can distort ration levels leading to incorrect nutrient levels that can harm a dairy nutrition program's performance. The typical ash content for perennial grasses is 7-12% on a dry matter basis. Ash does not contribute any calories (energy) to the diet [8]. In our trial the content of ash ranged from 5.46% *Fp* 'Kaita' (LT) to 6.79% *Fp* 'Arni' (EE) in the 1st cut and from 6.97% *Fp* 'Raskila' (LT) to 8.50 % *FxL* 'Vizule' (LV) in the 2nd cut.

CONCLUSIONS

All the species and cultivars under research are well suitable for forage production in Latvia, although the productivity depends on agro-climatic condition during the growing season and wintering. *Pp*, *Fp* and *Dg* cultivars are characterized by long and more stable persistence in sward. In the 5th year of use *Lp* cultivars disappeared greatly from the sward after black frost.

Higher and more stable yields over the 5 years of use accounted for *Pp* cultivars: 'Switch' (SE), 'Varis' (LV), 'Teicis' (LV) and perspective No '2690' (LT), which provided more than 7 t ha^{-1} DMY on average. Good average DMY with high forage quality during the 4 year period was provided by *FxL* cultivars 'Punia' (LT) and 'Saikava' (LV) – 7.33 and 7.19 t ha^{-1}, respectively.

In general the forage quality of all cultivars of *Lp*, *Fp* and *FxL* was satisfactory providing RFV over 100 for both mowings.

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WEATHER CONDITIONS EFFECT ON FRESH AND STORED WINTER WHEAT GRAIN GLUTEN QUANTITY AND QUALITY

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Abstract. *Gluten quantity and quality are important indices for technological processing of wheat. The objective of this study was to determine weather conditions effects for two different winter wheat cultivars on fresh and stored grain (60, 120 and 360 days) on wet gluten and quality. Field experiments with winter wheat (Triticum aestivum L.) cultivars 'Bussard' and 'Zentos' using nitrogen top – dressing rates (N60-N150) were carried out at the Study and Research farm "Peterlauki" of Latvia University of Agriculture, in 2009/2010, 2010/2011 and 2011/2012. Highly significant (< 0.05) effect of weather conditions were detected on the wheat wet gluten and quality. For the grain stored for 60-360 days, the content of wet gluten declined and the quality of gluten improved. The grain of cultivar 'Bussard' had significant higher wet gluten content and quality, compared to 'Zentos' (t< 0.05). Average data from the three experimental years suggested that gluten content in 'Bussard' grain was 284 g kg^{-1}, during grain storage 360 days it decrease by 25 g kg^{-1} while in 'Zentos' grain respectively 237 g kg^{-1} and 20 g kg^{-1}. Average gluten index in 'Bussard' grain was 80 units, during grain storage 360 days it increase by 8 units, while in 'Zentos' grain respectively 63 units and 9 units. The data averaged over three years show that gluten index correlation with wet gluten was strong inverse only for cultivar 'Zentos' r= – 0.765** while for 'Bussard' r= – 0.485. When both cultivars had highest gluten content (in 2010 and 2011), the relationship between these indicators was from r= – 0.120 to r= – 0.667. If the weather conditions for gluten accumulation were less favourable (in 2012) relationship between gluten content and gluten index for cultivar 'Zentos' grain was strong r= – 0.978**, while for 'Bussard' it was weaken r= – 0.921.*

Key words: *Wet gluten content, gluten index, grain storage.*

INTRODUCTION

Wheat is one of the cereals more grown and consumed in the human food in all worlds today. A high grain quality is important for food production.
The amount of wet gluten, as an indicator, is closely connected with baking quality of bread grains [1]. Gluten is a fundamental component for the overall quality and structure of breads. Gluten is capable of forming adhesive and cohesive masses, films and three-dimensional networks, all essential to baking performance and its content increases with the amount of total protein content. Gluten proteins can be categorized based on their solubility into gliadins (alcohol-water soluble) and glutenins (insoluble) Gliadins and glutenins are well known for their influence on the properties of gluten The gliadins create viscosity required for dough development, whereas the glutenins provide strength and elasticity of dough. The optimum ratio between glutenin and gliadin for high quality of gluten is found 1:1.1 [2].
Gluten content is highly dependent on the weather conditions of the year of cultivation and genotype [3],[4]. A cultivar depends not only on its genetic potential for particular characters but also on its ability to realize this potential in actual production and under different environmental conditions [4]-[7]. Wheat during grain ripening needs sunny and warm weather and moderate moisture it contributes to an increase in grain protein and gluten content [8],[9].
This research is a continuation of previous work (Liniņa and Ruža 2012) in which we investigated the quality of winter wheat freshly harvested grain (thrashing in 2010 and 2011) and during grain storage.
The aim of this investigation was to clarify variation of grain wet gluten and gluten quality depending on weather conditions in three investigation years and during grain storage.

MATERIALS AND METHODS

Study fields

Field experiments in 2010 and 2011 were conducted at the Latvia University of Agriculture, Study and Research farm "Peterlauki" on Endoprotocalcic Chromic Stagnic Luvisol (Clayic Cutanic Hypereutric), silty clay loam/

clay, organic mater 20-31 g kg^{-1}, pH KCl – 6.6-7.0 and medium phosphorus and potassium content easily utilized by plants. Winter wheat (*Triticum aestivum* L.) cultivars 'Bussard' and 'Zentos' (Germany) were sown after black fallow in four replications (rate of 400 germinating seeds per m^2).

Both wheat cultivars are of high bread-making quality (Elite cultivars), differing in their high molecular weight (HMW) glutenin composition.

Wheat 'Bussard' possesses subunit 1 at Glu–A1 locus α allele, and 'Zentos' possesses subunit 0, respectively. Both cultivars have the same patterns 7 + 9 at Glu – B1 c and 5 + 10 at Glu – D1 locus d alleles [10].

Nitrogen (N), was applied N60-150 kg ha^{-1} in spring after resumption of vegetative growth. All the necessary plant protection measures were performed. Grain was harvested at full ripeness. Freshly harvested grain of each variety was put into separate bags. The grain with a moisture content exceeding 14% was dried. Grain samples for analyses were taken for 60, 90, 120 and 360 days after harvest. Fully raped grains were stored in a storage house. The air temperature and relative air humidity in the storage house depended on the outdoor conditions.

Meteorological conditions

The air temperature in investigation years in April was by 0.8-2.5 ºC higher compared with long-term average observations (5.4 ºC); also May was by 0.3-1.3 ºC warmer, which promoted plant growth and development. Average daily temperature in June 2010 and 2011 was warmer by 0.9-2.0 ºC which contributed to the accumulation of protein and gluten content. In June 2012 air temperature was lower than 1.1 ºC, compared to long-term average data (15.2 ºC). Temperature in the grain filling period (July) was in 2010 by 4.4 °C warmer and by 2.7 °C warmer in 2011, while in 2012 only by 1.2 °C higher than the long-term average mean data (16.8 ºC).

Precipitation in April 2010 and 2011 was close to long-term average, but in 2012 by 265% more than long-term means data (40.0 mm). May in 2010 was wet, when precipitation was 164% higher than the long-term average for this month (51.4 mm), in 2011 and 2012 precipitation was close long-term mean data for this month. Precipitation in June 2010 and 2011 was close to long-term mean; but in 2012 by 126% more than long-term means data (75.3 mm). July in 2010, 2011 and 2012 was very rainy, respectively 298, 179 and 197 mm that two to three times exceeded the long-term averages data (81.7 mm).

Wheat technological analyses

Wheat quality indices were analyzed at the Latvia University of Agriculture, in Grain and Seed Research laboratory. Grains were milled to wholemeal flour using Perten Laboratory Mill 3100 with 0.8 mm sieve. Wet gluten content (WG) was washed from whole meal flour (14%) and gluten index (GI) was measured according to Perten (ICC 155, Glutomatic 2100, Centrifuge 2015, Perten Instruments, Sweden). The wet gluten quantity reported g kg^{-1} on a 14% grain moisture basis.

Statistical analysis

Experimental data evaluation was done using two-factor analysis of variance (ANOVA). Mean, standard error of the mean, coefficients of variation and least significant difference ($LSD_{0.05}$) were determined. Significant differences in gluten quantity and quality between both cultivars were tested by a t-test: two-sample assuming unequal variance. Correlation analysis between wet gluten and gluten index was also carried out.

RESULTS AND DISCUSSION

The major wheat flour constituent, which determines dough quality, is gluten. Wheat cultivars significant differ as to their grain quality. 'Bussard' grain was characterised by statistically significant ($t < 0.05$) higher wet gluten and gluten index than 'Zentos' grain. The variation sequence of grain wet gluten and gluten index was respectively CV 12.1 and 9.2% for 'Bussard' grain and CV 14.8 and 14.7% for 'Zentos' grain (Table 1).

Gluten content and quality on fully ripe winter wheat grains

Gluten content depends on the ratio of protein fractions in grain with is affected by plant supply with nutrients at grain ripening stage and weather conditions at the same stage [8],[11]. The gluten content in winter wheat grain significantly ($p < 0.05$) depended on the meteorological conditions of the investigated years (Fig. 1).

Grain processing companies in Latvia wet gluten could be classified into five classes. The first class (Elite) and second A class are referred to as very good with wet gluten above 280 g kg^{-1}, the third class is referred to as good with wet gluten above 260 g kg^{-1}, the fourth is considered wet gluten above 240 g kg^{-1} and the fourth fifth class is referred to as low with wet gluten below 200 g kg^{-1}.

Table 1

Variation of winter wheat grain wet gluten and gluten index, 2010–2012

Indices	Wet gluten (WG) g kg^{-1}	Gluten index (GI)
	'Bussard'	
Mean ± standard errror	272 ± 4.7	84 ± 1.1
min – max	210 – 335	71 – 98
Coefficient of variation (CV%)	12.1	9.2
	'Zentos'	
Mean ± standard errror	227 ± 4.8	68 ± 1.4
min – max	162 – 289	52 – 90
Coefficient of variation (CV%)	14.8	14.7

In 2010 and 2011 experimental years wet gluten content (after thrashing) 'Bussard' grain exceeded 300 g kg^{-1} and corresponding to Elite and A class while 'Zentos' grain was corresponding to third and fourth quality class (Fig. 1). Lower gluten content of the both varieties of the grain produced in 2012, when in June and July were a relatively lower temperatures (about 2.5 ºC) compared to 2010 and 2011. Gluten content in 2012 was lower on cultivar 'Zentos' and grains were inadequate food grain quality (197 g kg^{-1}) while the cultivar 'Bussard' grains were consistent with fourth quality class (243 g kg^{-1}). Similar scientific results were obtained in the trial Dotnuva (Lithuania) Cesevičiene and co-authors [12], they conclude, that warmer weather is more favourable for the concentration of protein content (also gluten content) in wheat grains. Cool (average air temperature in growing season 12.7 °C) and rainy weather in 2012 during grain filling-ripening stage was adverse for gluten accumulation.

A higher gluten index indicates stronger gluten**.** Gluten quality was determined by centrifugation method. The first quality group (61-90) of gluten is very good, second group (41-60) is satisfactory, third (> 90) unsatisfactory strong, but fourth (< 40) is unsatisfactory weak. Only grain containing gluten of the first or second gluten quality group is suitable for bread production [14]. M. Mikos and G. Podolska found that for baking purpose the wheat with gluten index of 50-60 is the best. When with an index of less than 50 is more difficult to process, the dough is sticky and is mainly suitable for biscuits [1].

In cultivar 'Bussard' grain gluten index ranged from 74 to 84 and corresponding to first quality group, while 'Zentos' gluten quality was lower from 55 to 72 and its grains was consistent with the first and second quality groups. There are some indications in references that when grain had higher gluten content, its quality declines [15],[16]. In our experiment this was confirmed only for cultivar 'Zentos' grains.

Changes gluten content and quality during grain storage

During storage wet gluten content in grain declined significantly ($p<0.05$). Changes of the wet gluten content after 60 days for cultivar 'Bussard' grain was 3-6 g kg^{-1} and for 'Zentos' 4-6 g kg^{-1}, after 120 days wet gluten decreased respectively by 6-20 and 6-8 g kg^{-1}, compared with fully raped grain. After 360 days (one year) wet gluten decreased for cultivar 'Bussard' grain 18-31 g kg^{-1} while for cultivar 'Zentos' grain 16-23 g kg^{-1}, compared with the initial values.

Average data from the three experimental years suggested that gluten content in 'Bussard' grain was 284 g kg^{-1}, during one year grain storage its decrease by 25 g kg^{-1} while in 'Zentos' grain respectively 237 g kg^{-1} and 20 g kg^{-1}.

As observed for both varieties, grain gluten was lower in 2012 trashed winter wheat grains, when air temperature in the vegetation period was lower and the gluten content in storage time was reduce less: in 'Bussard' grain by 18 g kg^{-1} while 'Zentos' 16 g kg^{-1}. If weather conditions are favorable for gluten formation in grains (in 2010 and 2011) then tended to lose more of it during grain storage.

During the initial 60 days of storage gluten became stronger. Gluten index was increase after 60 days for cultivar 'Bussard' grain 2-3 and for 'Zentos' 3-5 units, after 120 days gluten index rise respectively by 3-8 and 7-9 units, compared with fully raped grain. After 360 days gluten index increase for cultivar 'Bussard' grain 6-9 while for cultivar 'Zentos' grain 7-12 units, compared with fully raped grains values. Several other scientists [16],[17] also reported on significant increase of grain gluten index during grain storage.

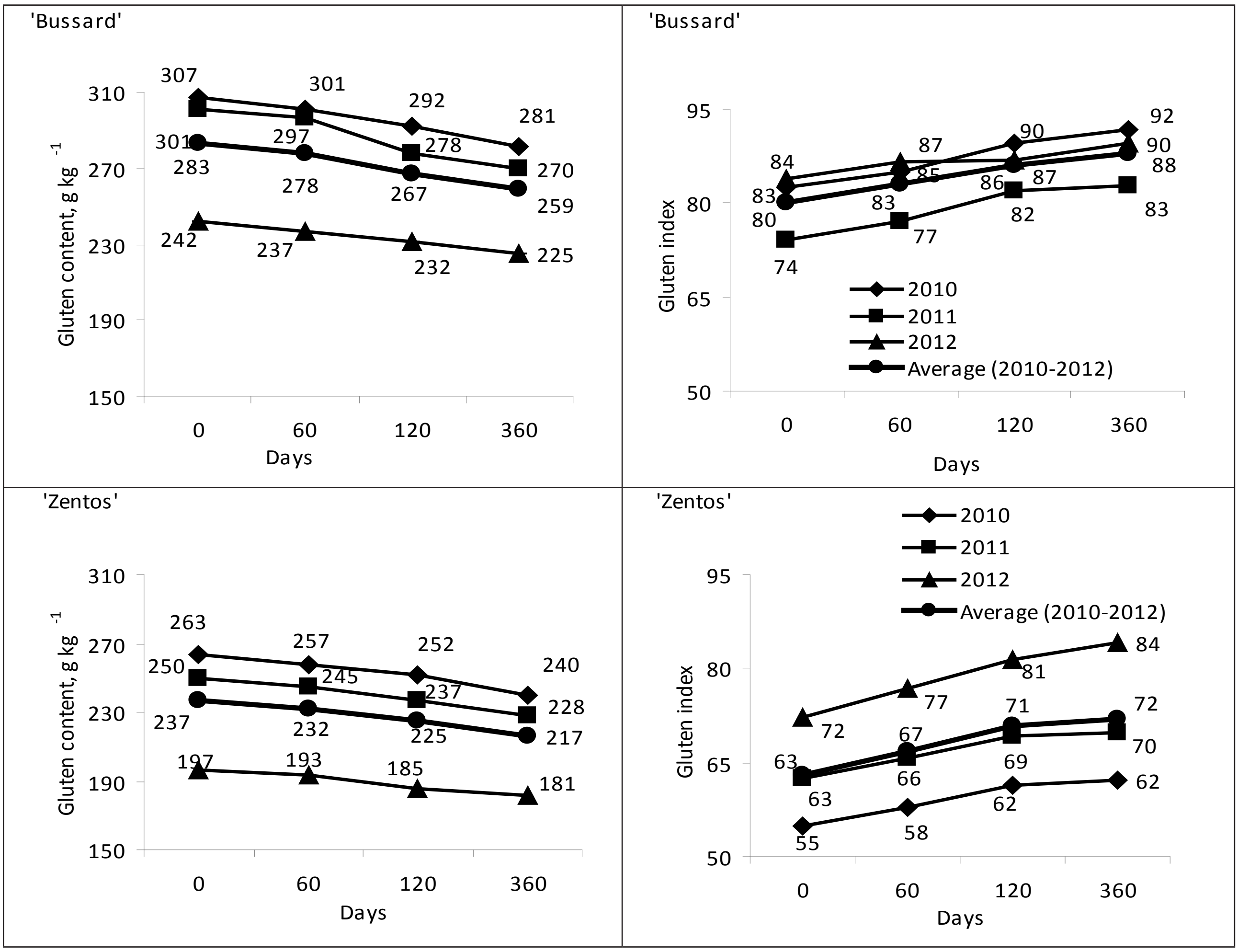

Figure 1. **Winter wheat grain gluten content, g kg^{-1} and gluten index depending on weather conditions in investigation years during grain storage**

The data averaged over three years indicated that gluten index in 'Bussard' grain was 80 units, during the one year grain storage it increase by 8 units, while in 'Zentos' grain respectively 63 units and 9 units. Gluten index increased during storage, it was important for cultivar 'Zentos', which gluten content in freshly harvested grain in 2010 was in the second quality class but during storage it became stronger and was above 62 units thus being a part of the first quality group.

The data averaged over three years show that gluten index correlation with wet gluten was strong inverse for cultivar 'Zentos' r= – 0.765** (n = 12, $a_{0.05}$ = 0.575, $a_{0.01}$ = 0.708), while for 'Bussard' r= – 0.485.

The correlation between gluten quality and gluten content was not the same in every year. When both cultivars had highest gluten content (in 2010 and 2011), the relationship between these indicators was from r= – 0.120 to r= – 0.667 (n = 4, $a_{0.05}$ = 0.950, $a_{0.01}$ = 0.990). Similar results obtained J. Cesevičiene in Lithuania [18]. When the weather conditions for gluten accumulation were less favourable (in 2012) relationship between gluten content and gluten index for cultivar 'Zentos' grain was strong r= – 0.978**, while for 'Bussard' it was weaken r= – 0.921. The different relationship between gluten content and its quality in the grain on the tested cultivars may have resulted from the fact that the cultivars differed in gluten content and quality: 'Bussard' grains gluten content and gluten index was higher than that of 'Zentos'.

CONCLUSIONS

During three trial years the quality of the studied winter wheat grain met demands set for food grain, except cultivar 'Zentos' grain in 2012. If during grain ripening is the warm weather with the lowest rainfall, gluten wheat is accumulated higher.

Gluten quantity and quality were affected most by the experimental year's weather conditions but the genotype of the cultivars had some impact on the variation as well.

Differences in grain gluten content and quality were noted when freshly harvested grain was compared with that stored for 60, 120 and 360 days. The findings suggest that during the storage period wet gluten content in the grain decreased. However, the gluten became stronger. There was significant reductions in wet gluten content for cultivar 'Bussard' grain 25 g kg^{-1} and increase in gluten index by 8 units, while for cultivar 'Zentos' grain 20 g kg^{-1} and 9 units respectively.

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EVALUATION OF TRAITS STABILITY FOR SELECTION PURPOSES IN POTATO BREEDING PROGRAMME

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Abstract. *One of the aims in potato breeding programmes is to develop varieties with high yield potential; essential for successful variety introduction into production additionally is yield stability in changing growing conditions. The quality and composition of important for human health substances became more important for competitiveness of food product. As well as evaluation of stability of quality traits become relevant task in development of new varieties. For evaluation yield stability dynamic concepts are recommended: parametric statistic methods – regression coefficient, ecovalence and several other approaches – and some nonparametric methods. For quality traits the static stability concept is more acceptable, like phenotypic or environmental variance and regression coefficient (Becker and Leon, 1988, Lemelin et al., 2005). The trial for trait stability evaluation methods assessment was carried out in three farming systems (2 conventional fields with different fertilisation and organic field) for three years (2011-2013), in total nine environments. Five potato varieties were involved in trial ('Agrie Dzeltenie', 'Lenora', 'Prelma', 'Brasla' and 'Imanta'). Yield, starch content in tubers, concentration of carotenoids, vitamins C and B1 in tubers (fresh weight) was detected for each variety in each environment. The data were analysed using analysis of variance (ANOVA) with two factors (variety and environment). The variety environmental variance (s^2) from ANOVA was one of traits stability assessment parameters – static. The regression approach (regression coeficient r_1) was also used for evaluation of traits stability. The ecovalnce (E) was used for stability evaluation in variety – environment interaction as dynamic concept (Becker and Leon, 1988). The s^2 and E were expressed in percentage of the total interaction sum of squares (Legzdina, 2013).*

The potato tuber yield was significantly determined by variety and environment ($p<0.05$). The average yield of varieties ranged from 26.8-44.4 t ha^{-1}.Yields of 'Brasla' and 'Prelma' exceeded mean yield level. Comparatively the parameter s^2 for 'Prelma' was lower, but E was higher than 'Brasla'. Parameter b_1 for both varieties was significant ($p<0.05$) and did not differ significantly from 1, it means that both varieties were quite high yielding and acceptable for different growing environments. As static stability evaluation concept (s^2) is inappropriate for yield evaluation, the dynamic concept E shows that more stable and simultaneously high yielding is 'Brasla'. Quality traits – starch content, concentration of vitamins C, B1 – was significantly determined by variety and environment ($p<0.05$), but concentration of carotenoids was significantly determined only by genotype ($p<0.05$), influence of environment was not significant ($p>0.05$). The highest starch content stability using s^2 and r_1 (lower values) was detected for 'Brasla' with higher starch content level, but applying E – for 'Lenora'. Evaluating stability of quality traits like concentration of vitamins C, B1 and carotenoids using s^2, r_1 and E with the lowest values, the best stability was detected for varieties with lower average trait value: vitamin C – 'Brasla', vitamin B1 – 'Prelma', carotenoids – 'Imanta'.

Key words: *potato, trait stability, yield, quality.*

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THE ANALYSIS OF CARBON CONTENT IN DIFFERENT ENERGY CROPS

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Abstract. *Local grass and water plant use is an important part in diversification of the energy sources. The various plants are one of the most important types of the local biomass, whose potential in Latvia until now is not being adequately used. The objective of this work was to determine the suitability of the biomass of reed (Phragmites australis (Cav.) Trin. Ex Steud), tall fescue (Festuca arundinacea Schreb.), festulolium (x Festulolium), reed canary grass (Phalaris arundinacea L.) as fuel. The carbon content in the biomass was determined using carbon/sulphur analyzer ELTRA CS–2000. Reeds are one of the widespread water plants in Latvia. The analyzed samples were collected from 11 natural and artificial water bodies. The field trials of tall fescue, festulolium, reed canary grass was carried out during 2011-2012 growth seasons in Research and Study Farm "Peterlauki" (56°53'N, 23°71'E) of the Latvian University of Agriculture. Plants were cultivated in the sod calcareous soils pHKCl 6.7, containing available P 52 mg kg^{-1}, K 128 mg kg^{-1}and organic matter content 21 to 25 g kg^{-1}. According to the results of the three-year study the carbon content in the reeds were 42.41 ± 0.18%. The carbon content is similar to various tall fescue – 47.55 ± 0.09%, festulolium 47.14 ± 0.14%, reed canary grass varieties 'Marathon', 'Bamse', 'Pedja' was 47.24 ± 0.09%. The carbon yield for one hectare was within the range 1.09-3.89 t ha^{-1}. It was dependent on the variety, plant age and nitrogen fertiliser use. Plant carbon content analysis established that biomass of reeds, tall fescue, festulolium, reed canary grass is suitable for energy generation. Carbon content in these plants is similar to that of the firewood.*

Key words: *carbon content,cammon reed, tall fescue, festulolium, reed canary grass.*

INTRODUCTION

Carbon dioxide (CO_2) and in the form of methane (CH_4), and the presence of these gases is a substantial influence on the atmosphere qualities (temperature level) and therefore the climatic conditions on the planet. Therefore the Carbon Oxide emission level increase can be a factor which negatively influences the governing environmental factors. By burning biofuels the same amount of CO_2 is distributed, as the plants take from the atmosphere; and therefore not increasing the global warming effect, reducing the harmful and toxic effects, which include the cancerogenic compounds, and emissions in the air; reducing illnesses connected with the respiratory organs in urban areas [7].

Carbon is the main burning element in fuel, producing a high burning temperature, and forming the main part of the burning mass [3],[16]. Burning carbohydrates, carbon dioxide and water are produced, and solar energy is released. This type of biomass is a natural, sustainable and infinite battery for the storage of solar energy.

The Carbon content in energy plants and fuel is influenced by diverse factors: 1) the fuel form and the location conditions [4],[6], 2) the variables for different plants, the varieties within a plant species and plant sections [2],[4], 3) the sampling period [1].

MATERIALS AND METHODS

In each of the lakes investigated: after inspecting the reed areas, four reed stands were selected, which according to the characteristics visually conformed to the average level in the specific water body. In each stand two sampling plots were investigated. From each sampling plot was taken about 1 kg reed biomass, which was used to establish the reed parameters in laboratory conditions. Even though previous research has shown, that reed stems and leaves have different abilities to accumulate chemical elements deposits [8]. In our research the reed stems were not separated from the leaves. As for harvesting the reed for fuel production, this type of separation is complicated and energy capacious, which increases the cost of reed processing. The reed samples collected from the eight sampling plots in each water body (Lubanas lake, Kvapanu ponds, Idenas ponds, Luknas lake, Cirisa lake, Sivera lake, Rusonas lake, Feimanu lake, Raznas lake, Cirmas lake, Ludzas lake) were combined producing an average sample. The reeds were chopped up, and for the laboratory research 1 kg of the reed fragments was taken as an average sample.

Reed canary grass (RCG) varieties 'Marathon' and 'Bamse' were carried out in sod-podzolic loamy soil (the organic content of the soil – 5.2%, pHKCl – 5.8, P_2O_5 – 20 mg kg^{-1}, and K_2O – 90 mg kg^{-1} of the soil) in the Agricultural Science Centre of Latgale. The area of the plots was 16 m^{-2}, the location of the plots was randomised. The RCG was sown after bare follow. Before sowing a complex fertiliser was applied N:P:K – 5:10:25 – 400 kg ha^{-1}. The RCG varieties 'Marathon' and 'Bamse' were sown in April 2009 and 2010. The samples for the laboratory research were collected in October 2009 and 2010.

The carbon content in the biomass was determined using carbon/sulphur analyzer ELTRA CS–2000 in Chemical laboratory of Rezekne higher education institution. The plant length was determined for five plants on each repeat occasion (for all plant stalks). The reed canarygrass samples were taken on the 12th October 2009, 6th October 2010. The meteorological conditions were different in both trial years. The meteorological conditions for agriculture during 2009 the plant growth period had a significant deficit in rainfall. The temperature was in compliance with the long term yearly long-term average. In the winter of 2009/2010 snow was observed to be greater and the temperature was lower than the long term yearly long-term average. On the 23rd and 24th of April 2010 there was snow and hail. The plant growth period in 2010 was characterized by higher temperatures and a lack of precipitation in April, July, August and September.

Research objects: RCG (*Phalaris arundinacea* L.) and tall fescue (*Festuca arundinacea* Schreb.) that are perennials yielding for 8-10 years, plant length up to 1.5 m, they are modest in terms of requirements for soil and may grow in marginal soils, moreover they are suitable for cultivation in moisture meadows, with strong root system and excels also with durability against draughts cold tolerance.

The field trial was carried out during 2011–2012 in Research and Study Farm "Peterlauki" (56°53'N, 23°71'E) of the Latvia University of Agriculture, in the sod calcareous soils pHKCl 6.7, containing available for plants P 52 mg kg^{-1}, K 128 mg kg^{-1}, organic matter content 21 to 25 g kg^{-1} in the soil. The field test fertiliser norms applied were following (kg ha^{-1}): $N_0P_0K_0$ (control) P_2O_5 – 80, K_20 – 120 (F – background), F+N30, F+N60, F+N90, F+N120 (60+60), F+N150 (75+75), F+N180 (90+90). Seed sowing norm – 1000 germinant seeds per 1 m^{-2}; usage type: mowing two-three times.

Carbon (C) content in various samples was found out in the agricultural scientific laboratory for agronomic analyses of the University of Latvia in compliance with the measured using the analyser 'ELTRA CS–500 Analyzer'.

The trial data were processed using correlation and variance analyses of two and three factors (ANOVA) and descriptive statistics. The means are presented with their LSD test. Representative average samples of the indicators were used in the calculations.

RESULTS AND DISCUSSION

Carbon is one of the important elements in ensuring the efficiency of the photosynthetic process, when from non-organic matter, under the impact of solar light, organic matter is created. Even though photosynthesis is a non-effective process, as the most productive plants can only convert 6% of the solar energy [5]. Carbon is also the main burning element in fuel. Carbon has a high burning temperature, and it makes up the greatest part of the burning mass [3]. As cereal grasses are used for granule production, then it is important to evaluate the carbon content. For the lake reeds the carbon content was 42.41 +/–0.18% (Table 1). For the lake reeds changes in carbon content for each of the three years researched did not exceed a 5% range.

The scientists from the Latvian State Forest Research Institute "Silava" in their research have found that in the reed canary grass dry matter there was 49% carbon [9]. In our research the carbon content was 37.65-39.87% (Table 2), which shows that the carbon content is influenced by several relevant factors. Carbon content in reed canary grass dry matter was found to be on average 38.3 ± 0.5%.

Table 1

Carbon content in lake reeds, %

Year	Average	Min	Max	Standard error
2010	42.71	41.62	44.21	0.24
2011	42.61	41.39	43.76	0.23
2012	41.90	40.50	44.35	0.42
3 year average	42.41	40.50	44.35	0.18

Carbon content is influenced by the plant age: for the year 2009 autumn harvest dry matter the carbon content was in the range 37.45-40.68%, but in the following year – 40.07-41.88%. The greatest carbon content was found in the reed canary grass 'Marathon', Carbon yield from one hectare was in the range 1.09-3.89 t ha^{-1}. It was dependant on the variety, plant age, and the nitrogen fertilizer norm.

Table 2

Carbon content in reed canary grass, %

Variety	Year	Average	Min	Max	Standard error
'Marathon'	2009	38.79	37.45	40.68	0.36
	2010	40.96	40.07	41.88	0.25
	Average	39.87	37.45	41.88	0.31
'Bamse'	2009	36.92	35.55	40.07	0.55
	2010	38.38	36.58	40.68	0.44
	Average	37.65	35.55	40.68	0.38

The agro meteorological conditions for the trial year (F_A), as a factor for the chemical composition influencing proportions is different for the two reed canary grass varieties [15] (but of fundamental importance (Table 3).

The influence of the agro meteorological conditions was observed to be greatest on the carbon content in the reed canary grass variety 'Marathon' (η = 66%). A lower influencing proportion was observed for the nitrogen fertilizer norm (F_B). The factor interaction for the variety 'Bamse'(η = 71%) and for the variety 'Marathon' (η = 12%) shows, that each variety reacts differently to the environmental conditions (Table 3).

Table 3

The factor influencing proportions for reed canary grass carbon content (P<0.001), η, %

Variety	Factors		
	Harvesting time – F_A	Nitrogen fertiliser norm – F_B	Interconnection between F_A un F_B
'Marathon'	66	21	12
'Bamse'	17	13	71

The undesirable elements in plants As, Cd and Pb form a close fundamental negative correlation in connection to carbon (Fig.1 which can adversely affect the plant development and the quality of the hard fuel. The heavy metals are phytotoxic, especially as, they can interact with various elements in a synergic and antagonistic way, which is also dependant on the soil pH [12]. In the reed canary grass trial plots the soil pHKCl was 5.8.

For reed canary grass, the alkali and alkalisoil metals are organically fixed in various carbon structures [10],[11],[14]. Reed canary grass dry matter at the start of the ash melting, the hemisphere point, the ash flow temperature forms a negative linear correlation with carbon content ($r = –0.52$; $r = –0.49$; $r = –0.49$; $P < 0.001$; $n = 36$).

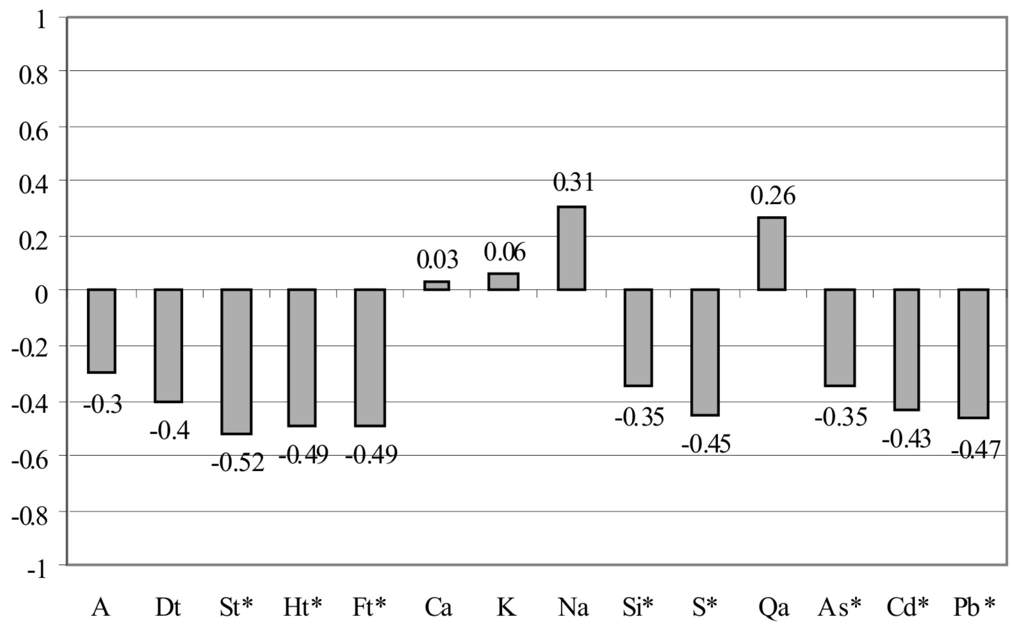

Figure1. **Correlation with carbon content, where Dt – deformation start temperature, St – ash melting start, Ht –hemisphere point, Ft – ash flow temperature, A – ash content, Qa – greatest thermal capacity, * – P<0.001.**

Sowing reed canary grass in different years and different soil conditions, it can be seen that the carbon content is nearly 10% greater (Table 3). For cultivated tall fescue and festulolium the carbon content is similar – 47%. For the varieties ‘Marathon’ and ‘Bamse’ the carbon content varies in the range 0.55 and is similar in tall fescue and festulolium.

Table 3

Carbon content in cereal grasses for the year 2012, %

Crops	Variety	Average	Min	Max	Standard error
Reed canary grass	‘Marathon’	47.71	47.21	48.11	0.07
	‘Bamse’	47.24	46.57	47.90	0.09
	‘Pedja’	46.50	45.95	47.57	0.14
Tall fescue		47.55	47.07	48.19	0.09
Festulolium		47.14	46.28	48.05	0.14

The carbon content in biomass varies in the range 42-71% while in the C peat and coal it is 56-87% [13]. In our research the results show, that the conditions for cultivation have a substantial influence on the carbon content.

CONCLUSIONS

The carbon content for energy plants was substantially influenced by the agro meteorological conditions in the trial year.

The carbon content in lake reeds is about 42%, in reed canary grass it is 37-47%, in tall fescue and festulolium 47% for the biomass dry matter.

The phytotoxic elements As, Cd, and Pb form close fundamental negative correlations with carbon, reed canary grass dry matter at the start of the ash melting, the hemisphere point, and the ash flow temperature which forms a negative linear connection with the carbon content.

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ROLE OF FERTILISERS ON PERENNIAL RYEGRASS SEED PRODUCTION AND FORAGE QUALITY

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Abstract. *Perennial ryegrass is a short-lived bunch-grass with shallow root system and suitable for grazing. It is a major component in different seed mixtures that are used for grassland management and forage production. Ryegrass requires high fertility level for good production especially adequate nitrogen supply. The objective of presented research was to study the effect of fertilisers for seed yield and forage quality of perennial ryegrass. (Lolium perenne L.) 'Spidola' (4n) – a popular forage grass cultivar in Latvia – using different NPK fertiliser application rates. Field experiments was carried out at the Skriveri Research Institute of Agriculture on sod-podzolic sandy loam soil (LuvicPhaeozem, WRB 2014), pHKCl 6.5, plant available P_2O_5 95 and K_2O 132 mg kg^{-1} (Egner–Riehm), soil organic carbon 20 g kg^{-1} (Tyurins' method). The following mineral fertilizer rates were used: N and P_2O_2, each 0, 30, 60, 90, 120, K_2O – 0, 40, 80, 120, 160 kg ha^{-1}. A randomised complete block design with four replications was used. Obtained 3-year average seed production was from 311 to 727 kg ha^{-1}, but in 2nd production years – from 102 to 617 kg ha^{-1}. The highest 3-year average was obtained usingN90 P30 K120 fertiliser application. Increases fertiliser rates increased lodging. The crude protein content in grass ranged between 80-118 g kg^{-1} in dry matter (DM). At the end of heading stage, perennial ryegrass had comparatively high crude fibre content (267 to 289 g kg^{-1} DM) at all treatments that significantly affected digestibility of forage. The average biomass yield from perennial ryegrass was 2.11-5.77 t ha^{-1} (on DM basis). The average chemical composition (on DM basis, g kg^{-1}): P 2.1-3.0; K 16.5-2.9; Ca 2.4-3.4; Mg 1.2-1.6.*

Key words: *perennial ryegrass, fertility levels, seed production, forage quality.*

INTRODUCTION

Perennial ryegrass *(Lolium perenne* L.) is one of the most important grass species of temperate regions [1],[2]. The perennial ryegrass has several important performance characteristics, which account for their widespread use and popularity. Among them are high herbage yield, long growing season, tolerance to a wide range of environmental conditions and grazing practices, rapid seedling establishment, weed suppression, excellent persistence under close grazing, compatibility with white clover, and high seed and forage yield as well as palatability [3],[4].

Tetraploid ryegrass cultivar 'Spidola' has improved winter hardiness and its vegetative growth period from start of growth to seed maturation is 115 days. It has shorter plant length, with wider, darker leaves as compared with parent cultivar. This cultivar has excellent response to nitrogen fertilizer application and is suitable for the grass seed production. Growth and seed yield is very good. 'Spidola' is well suited for use in grass mixtures for late season forages and hay production. The objective of this research was to determine seed yield and forage quality for perennial ryegrass 'Spidola" at different rates of mineral nutrition.

MATERIALS AND METHODS

Field experiments were conducted on sod podzolic sandy loam soil (Luvic Phaeozem, WRB 2014) [5], pHKCl 6.5, plant available P 48 and K 169 mg kg^{-1} (Egner–Riehm), soil organic carbon 12.2 g kg^{-1} (Tyurin's method). The plots were established according to randomised complete block design in four replicates. The plot size was 17 m^2. Perennial ryegrass cultivar 'Spidola' was planted after field preparation in the amount of 12 kg $ha^{-1.}$

The following mineral fertilizer rates were used: N and P_2O_5 each of them 0, 30, 60, 90 and 120 kg ha^{-1}, K_2O – 0, 40, 80, 120 and 160 kg ha^{-1}.

Weed control was performed using MCPA herbicides (l liter ha^{-1} in the mixture with 8-10 g ha^{-1}granstar). Lodging of the perennial ryegrass stand was evaluated during the growing season using a scale from 1-9 (1 = the stand is completely lodged, 9 = lodging is not observable). The seed and straw yield was determined. Seed yield was recorded for the 1st year sward use.

RESULTS AND DISCUSSION

The effect of NPK fertilisation on seed and straw yield is shown in Table 1. Application of N fertiliser had a pronounced effect on seed and straw yield over the average of 3-year period. Phosphorus and potassium application had little, if any, effect. Without N fertiliser, the seed yield ranged from 311 to 379 kg ha^{-1}. The addition of 30 to 120 kg ha^{-1} of N annually increased the seed yield between 536 and 727 kg ha^{-1}.
Increased N application increased lodging as described in literature [6]-[8]. Seed yield response of cool-season grasses to spring-applied N is usually limited because of lodging. Lodging of perennial ryegrass (*Lolium perenne* L.) seed crops is a widespread problem. The estimated lodging resistance was 8.8 scores in perennial ryegrass plots receiving no fertiliser NPK (Table 1). Lodging resistance decreased in plots with increased NPK fertilizer rates. Relatively good perennial ryegrass seed yield could be attained if lodging resistance is around 6-7 scores.

Table 1

Effect of mineral fertiliser application rates on seed and straw yield of perennial ryegrass 'Spidola'

Fertiliser, kg ha^{-1}			Lodging resistance, points 1-9	1st year, kg ha^{-1}	
N	P_2O_5	K_2O		seed yield*	straw yield*
0	0	0	8.8	311	1958
0	60	80	8.6	379	2224
30	30	40	6.9	536	3281
30	30	120	6.2	552	3633
30	90	40	6.8	538	3583
30	90	120	6.5	572	3775
60	0	80	5.4	598	4377
60	60	0	5.3	569	4267
60	60	80	4.8	617	4305
60	60	160	4.2	658	4892
60	120	80	4.4	594	4643
90	30	40	3.1	625	4756
90	30	120	2.5	642	5279
90	90	40	2.7	713	5060
90	90	120	3.1	693	5480
120	60	80	2.1	700	5822
120	120	160	2.3	727	5918
Average			4.9	591	4309
$LSD_{0,05}$			0.9	52.8	576

*3-year average
9 – free from lodging

Perennial ryegrass tetraploid *cv.* 'Spidola' was developed at the Skriveri Research Institute of Agriculture of the Latvia University of Agriculture. Perennial ryegrass on the first cut produced the highest DM yield (2.1-5.8 t ha^{-1}) using increased mineral fertiliser rates. The ranges of data obtained are presented in Table 2.

Table 2

Dry matter yield and chemical composition of perennial ryegrass 'Spidola' (first cut, mean 2 years)

Fertiliser rate, kg ha^{-1}			DM yield, t ha^{-1}	Content in DM, g kg				
N	P_2O_5	K_2O		CP	CF	Ash	Fats	Digestibility
0	0	0	2.1	77.4	266.7	4.38	2.25	59.65
0	60	80	2.4	80.3	273.6	4.47	2.26	58.65
30	30	40	3.3	83.3	263.2	4.53	2.44	60.83
30	30	120	3.8	83.3	260.0	4.49	2.56	61.02
30	90	40	3.6	81.4	255.5	4.35	2.58	60.69
30	90	120	3.8	83.8	272.8	4.74	2.68	59.40
60	0	80	4.1	85.6	255.9	4.57	2.73	60.66
60	60	0	4.1	85.9	258.4	4.36	2.44	61.78
60	60	80	4.4	82.1	264.4	4.63	2.65	62.46
60	60	160	4.6	91.3	272.8	5.05	2.70	60.23
60	120	80	4.2	86.5	257.9	4.78	2.92	62.44
90	30	40	5.1	93.3	275.5	4.50	2.72	57.52
90	30	120	5.0	101.0	272.4	5.22	2.82	57.52
90	90	40	4.7	95.9	274.9	5.31	3.09	60.73
90	90	120	5.5	95.9	272.8	5.31	2.85	60.77
120	60	80	5.8	107.1	289.2	5.64	3.34	58.76
120	120	160	5.4	118.1	272.2	6.09	3.62	59.38
$LSD_{0,05}$			0.5	9.4	17.3	0.37	0.45	3.37

Table 3

Chemical compositionof perennial ryegrass 'Spidola' (first cut, mean 2 years)

Fertiliser rate, kg ha^{-1}			Chemical composition, g kg^{-1}			
N	P_2O_5	K_2O	P	K	Ca	Mg
0	0	0	2.1	16.5	2.4	1.2
0	60	80	2.1	16.5	2.4	1.3
30	30	40	2.1	17.6	2.6	1.3
30	30	120	2.0	17.8	2.8	1.3
30	90	40	2.1	17.0	2.7	1.3
30	90	120	2.4	18.3	2.5	1.3
60	0	80	2.0	18.0	2.7	1.3
60	60	0	2.2	16.8	2.8	1.4
60	60	80	2.1	17.7	2.6	1.3
60	60	160	2.4	20.9	3.0	1.4
60	120	80	2.5	18.8	2.5	1.4
90	30	40	2.2	17.6	2.9	1.3
90	30	120	2.3	20.4	2.9	1.4
90	90	40	2.4	19.7	2.9	1.5
90	90	120	2.5	20.5	2.9	1.4
120	60	80	2.6	19.8	3.2	1.6
120	120	160	3.0	22.9	3.4	1.5
$LSD_{0,05}$			0.2	1.5	0.3	0.1

At the end of heading stage, perennial ryegrass 'Spidola' gave comparatively high crude fibre content (256 to 289 g kg^{-1} DM) at all investigated mineral fertiliser rates that significantly affected the chemical composition and digestibility of forage. Crude protein content in perennial ryegrass at this developmental stage is 77-118 g kg^{-1} DM and mineral content is 43.8-60.9 g kg^{-1} DM.

Optimal values for ruminants nutrition for K (20 g kg^{-1} DM), Ca (3-7 g kg^{-1} DM) and P (2 g kg^{-1} DM) are realized through forage obtained. Mg concentration exceeding 2.0 g kg^{-1} DM, is given as a critical value for hypomagnesaemia in farm animals. In our investigations P, K and Ca changed within the range of these parameters, but Mg content accounted only for 1.2-1.6 g kg^{-1} DM (Table 3).

CONCLUSIONS

Fertilisation especially the use of nitrogen stimulates plant growth and development and as a result increases of seed and straw yield.

Higher seed yield was obtained at minimal (6-7 point) sward lodging.

The first year seed yield of perennial ryegrass cultivar 'Spidola' was in the range 311-727 kg ha^{-1} depending on weather conditions and fertilisation.

Application of balanced quantities of N, P and K fertilisers provides comparatively high DM yield of perennial ryegrass with good herbage quality.

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INFLUENCE OF NITROGEN FERTILIZER ON PERENNIAL GRASS DRY MATTER YIELD AND SUITABILITY FOR HEAT PRODUCTION

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Abstract. *Nowadays agriculture requires high-quality perennials with specific chemical composition that allows using them in bioenergy production. Sufficient amount of nutrients ensures favourable conditions for long-term use of soil resources and for high crop yield. Fertilizers along with climatic and soil conditions are vital for crop productivity and for yield quality. Nitrogen is significant for plant life processes; it is one of the main nutrients for grasses, it is important for yield and yield quality. Production of heat requires growing of plants with high biomass, high combustion ability, high heat output and low ash content. The aim of the research was to study dry matter yield of RCG and tall fescue depending on N fertilizer doses applied and to analyse the suitability of RCG and tall fescue dry matter yield for biofuel (pellet) production. In 2011-2012, the field trial was conducted in the Research and Study Farm "Pēterlauki". During the research, the influence of different doses of nitrogen fertilizer on the dry matter yield of reed canary and tall fescue had been analysed. It was found out that application of N more than 30 kg ha^{-1} allowed to increase the dry matter yield of reed canary grass by 1.08-3.93 t ha^{-1} or by 21.05-75.44%. For tall fescue, application of N more than 30 kg ha^{-1} allowed to increase the dry matter yield by 1.94-6.94 t ha^{-1} or by 21.64-119.1%.*

Key words: *perennial grass, dry matter yield, nitrogen.*

INTRODUCTION

In grass cultivation, specific attention should be devoted to biomass production and energy performance. Only productive grass is able to ensure positive energy balance in production of biofuel. Various species of grasses (*Poaceae*) may be grown for biomass production. In comparison with legumes, the productive longevity of grasses is higher. Grasses are less demanding for soil fertility and moisture regimes, produce high yields (up to 8-12 t ha^{-1}) and are perennial plants (up to 10 years) [1],[2].

Such grass species as reed canary grass (RCG) (*Phalaris aruindinacea* L.), tall fescue (*Festuca arundinacea* Schreb.), festulolium (× *Festulolium* Asch & Graebn.), meadow fescue (*Festuca pratensis* Huds.), timothy (*Phleum pratense* L.) are considered to be more suitable for bioenergy production [3],[1],[2].

Nitrogen (N) is significant for plant life processes; it is one of the main nutrients for grasses, it is important for yield and yield quality. An optimal N fertilizer dose is one that, when being increased, it does produce higher yield, but does not have negative influence on environment [4]. Fertilizing, agro-climatic and soil conditions are factors of a major significance for yield and quality of plants. Fertilizers allow acquiring higher yields. RCG biomass currently is considered to be one of the alternative sources for pellet production within the territory of Latvia, in Baltics and Northern Europe. These species are characterised with persistence to local climatic conditions and high biomass yield.

Effective use of nutrients is important for sustainable agricultural production. Sufficient amount of nutrients ensures favourable conditions for long-term use of soil resources and for high crop yield. Fertilizers along with climatic and soil conditions are vital for RCG productivity and for yield quality. The European Union sets high targets for the production of biofuels. This requires high energy yields and efficient use of available agricultural land [4],[1].

Heat production needs crops with high biomass, good combustion ability, heat output and low ash content. Ash is an indicator for the amount of non-combustible minerals in fuel. It is composed by minerals that do not burn during fuel combustion, i.e. those are inorganic substances [5]. Too high volume of ash leads to problems with automation of burning process, in addition thermal capacity of such solid fuel is by 600-1000 kJ kg^{-1} lower [5]. Ash content for grasses may comprise 1-20%; it may be affected by species, soil texture, moisture, mowing time. Standards set that ash content in timber should be 1.5%. Combustion heat of fuel is significant quality indicator that mostly depends on moisture and ash content. With average pellet moisture 6.7-7.8% it varies between 18400 kJ kg^{-1} and 17700 kJ kg^{-1} [5]. Ash content in RCG is much higher than in wood materials (0.5-3.0%), while notably lower than in coal (approximately 25%) [6]. Ash content in grass biomass is significantly higher than in timber [7].

Use of RCG for heat production is characterized by major problems in burning process, such as potassium corrosion in superheaters; reduction of ash melting point; high quantities of ash that may affect mechanism of pyrolysis. Herbaceous fuels (also RCG) contain potassium as their principal ash-forming constituents. Potassium is the dominant source of alkali in most biomass fuels [8].

One of the most important problems encountered in Latvia agriculture is acquisition of high-quality perennial grass plants with definite chemical content, ensuring that they may be used for the production of bio-energy, i.e. solid fuel (pellets, briquettes).

Cultivation of grasses for production of pellets and briquettes has recently become successful industry in Europe. Grass pellets have great potential in energy production, as these are small-sized and may be produced and consumed in one particular place. Pelleted grass thereof may become main fuel in Latvia regions, rural municipalities and small businesses. Main benefit of grass cultivation and utilisation is a decrease of carbon dioxide emitted during whole production process [2].

The aim of the research was to study dry matter yield of RCG and tall fescue depending on N fertilizer doses applied and to analyse the suitability of RCG and tall fescue dry matter yield for biofuel (pellet) production.

MATERIALS AND METHODS

The objects of research were two perennials: reed canary grass (*Phalaris arundinacea* L.) and tall fescue (*Festuca arundinacea* Schreb.). They are yielding for 8-10 years, have plant length up to 1.5 m, they are unpretentious for soil and may grow on marginal lands. Moreover, they are suitable for cultivation in moisture meadows, have strong root system and excel with cold tolerance, high yields [1],[2].

The field trial was carried out during 2011–2012 in research and study farm "Pēterlauki" (56°53'N, 23°71'E) of the Latvia University of Agriculture. Samples were grown in sod calcareous soil with pH_{KCl} 6.7, containing 52 mg kg $^{-1}$ P_2O_5 and 128 mg kg $^{-1}$ K_2O, organic matter content 21-25 g kg^{-1}. Nitrogen fertilization in the amount of 0, 30, 60, 90, 60+60, 75+75, 90+90 kg ha^{-1} was applied. Split doses of nitrogen fertilizers were applied first time at the beginning of spring vegetation and second time after first cutting. At the start of vegetation 80 kg ha^{-1} P_2O_5 and 120 kg ha^{-1} K_2O were used. Seed sowing norm was 1000 germinant seeds per 1 m^2; usage type: mowing two-three times.

Ash content in different samples was found out in the agricultural scientific laboratory for agronomic analyses of the University of Latvia in compliance with the ISO 5984: 2002/Cor 1: 2005 standard. The volume of sulphur and carbon in pellet samples was found out by using analyser "Eltra CS-500 Analizator". Lignin was measured in line with LVS EN ISO 13906:2008, ash in compliance with ISO 5984:2002/Cor 1 : 2005, wood fibre according to ISO 5498 : 1981, acid detergent fibre (ADF) with LVS EN ISO 13906 : 2008, nitrogen with LVS EN ISO 5983 – 2 : 2009, and potassium in line with the LVS EN ISO 6869:2002. For each sample three parallel experiments were carried out, repeating each tested combination three times. The correlations were analysed as linear or polynomial regressions, and graphs were made using MS Office program Excel.

RESULTS AND DISCUSSION

Dry matter is a combustible part of solid fuel; therefore dry matter yield is very important for heat production as it serves as an indicator for evaluation of suitability of biomass for fuel production. The volume of energy depends on the dry matter yield. Nitrogen (N) fertilizers are very significant for increasing biomass productivity, because it is the key plant nutrient for plant growth and development. The results showed that increased N fertiliser dose promotes higher dry matter yield. N fertilizer in all versions left positive effect on dry matter yield (Fig. 1). The application of N more than 30 kg ha^{-1} allowed to increase the dry matter yield of reed canary grass by 1.08-3.93 t ha^{-1} or by 21.05-75.44%. For tall fescue, application of N more than 30 kg ha^{-1} allowed to increase the dry matter yield by 1.94-6.94 t ha^{-1} or by 21.64-119.1%. The highest RCG dry matter yield (9.06 t ha^{-1}) was produced with N fertilizer dose 90+90 kg ha^{-1}. The highest tall fescue dry matter yield (11.24 t ha^{-1}) was produced with N dose 60+60 kg ha^{-1}, however with bigger N dose (75+75 or 90+90 kg ha^{-1}) the tall fescue dry matter yield reduced.

Ash is what remains when biomass fuel is burnt; for timber it is approximately 0.5%, while for agricultural products, e.g., straw, remaining ash amount reaches even 12% [10]. The results showed that ash content in this research (with various N fertiliser doses) in RCG dry matter yield was 7.02-8.88 %, while for tall fescue it was 7.93-8.88%. Low positive correlation between the ash content and the dry matter yield was found (Fig. 2).

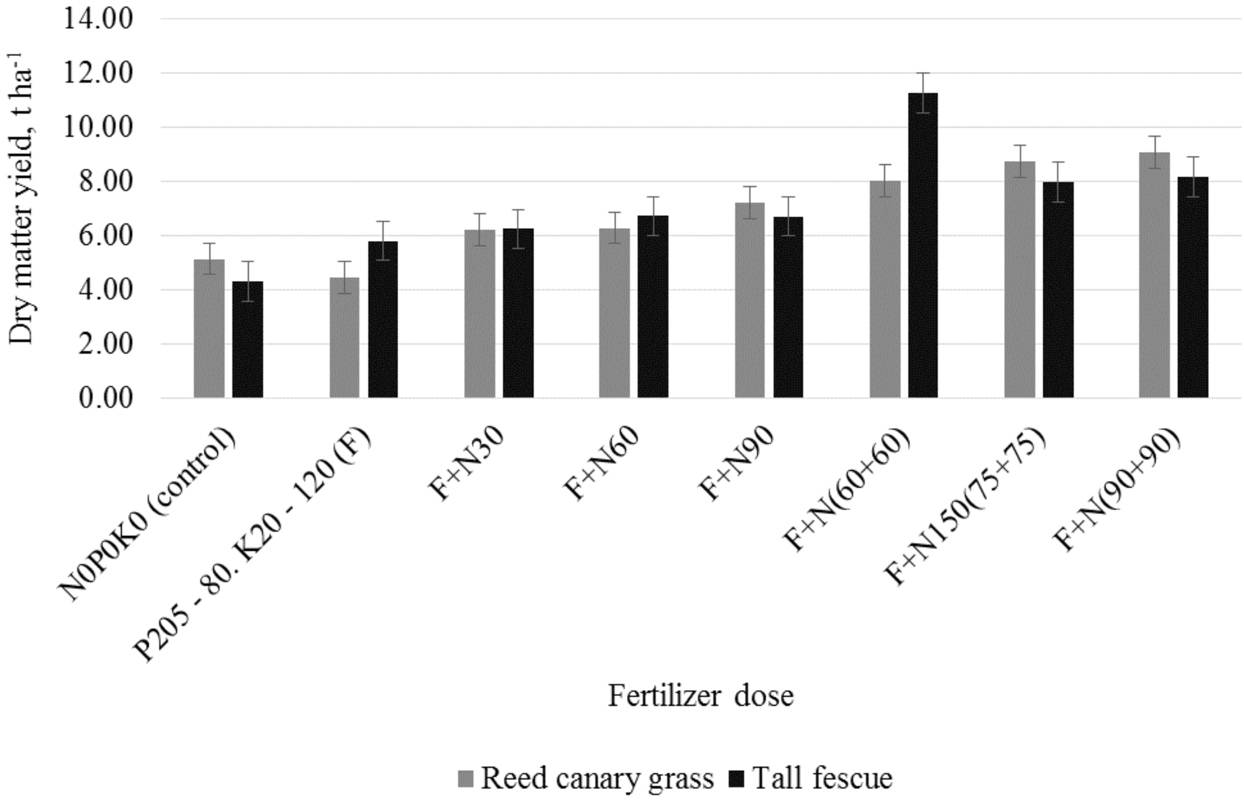

Figure 1. **Average dry matter yield of reed canary grass and tall fescue depending on nitrogen fertilizer dose**

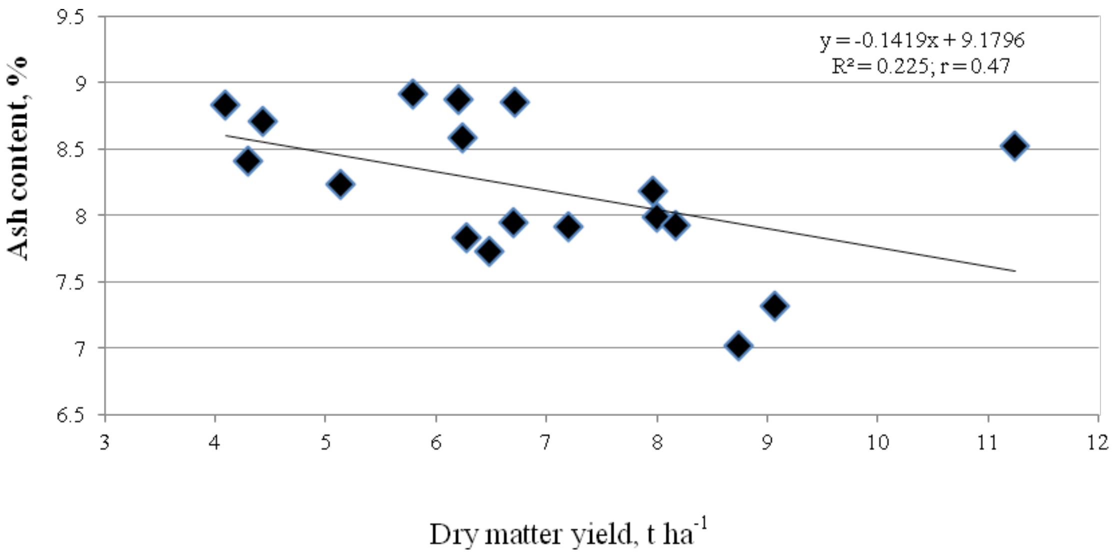

Figure 2. **Ash content in reed canary grass and tall fescue depending on dry matter yield**

For comparison, research conducted in Lithuania have found out that N fertilizers diminish ash content in crop biomass [11].

The results showed that application of N more than 60 kg ha^{-1} allowed to decrease the ash content of reed canary grass by 0.25-1.22%. For tall fescue, application of N 90 kg ha^{-1}, 150 (75+75) kg ha^{-1}, 180 (90+90) kg ha^{-1} allowed to decrease the dry matter yield by 0.46%, 0.23% and 0.48% respectively.

It was observed that 85–95% of plant nutrients (Ca, Mg, K, P) in ash (from burning of solid biofuel) occur in "usable ash" mixture of bottom and cyclone fly ash [12].
Significant correlation between dry matter yield and ash, phosphorus and carbon content was found for RCG. For the tall fescue, significant correlation between dry matter yield and potassium or sulphur content was found (Table 1). It means that application of N fertilizers does not have effect on grass biomass utilisation for heat production.

Table 1

Correlations between dry matter yield and fuel parameters for reed canary grass and tall fescue

Fuel parameters	Reed canary grass		Tall fescue biomass	
	R^2	Regression equation	R^2	Regression equation
Ash, %	0.622	y = -0.3011x + 10.018	0.1099	y = -0.0576x + 8.856
Lignin, %	0.0074	y = -0.015x + 5.1361	0.0536	y = -0.042x + 5.6499
Nitrogen (N), %	0.1222	y = 0.0163x + 0.8452	0.1815	y = 0.0221x + 0.7819
Phosphorus (P), %	0.8303	y = -0.0134x + 0.397	0.2701	y = -0.0035x + 0.2663
Potassium (K), %	0.0031	y = 0.002x + 1.8929	0.6773	y = 0.0726x + 1.5562
Carbon (C), %	0.6171	y = 0.1337x + 46.653	0.0003	y = -0.0024x + 46.245
Sulphur (S), %	0.3482	y = -0.0018x + 0.0822	0.5229	y = -0.0042x + 0.1155
Wood fibre, %	0.2023	y = 0.2616x + 29.648	0.001	y = -0.0206x + 31.65

Dry matter yield has effect on the choice of combustion technology, as well as it influences on total biomass energy transformation costs [10]. German scientists [13] in research on multivariate regression analysis proved that biomass quality parameters are influenced by yielding time and climatic conditions (rain) present during the whole growing period [13].
As compared to other researches, ash content found within this research is slightly higher and ranges between 8 and 8.5%, while lignin content is lower – only 5-5.4%. Therefore, utilisation of biomass gives importance to technologies ensuring higher efficiency during combustion. Agro-climatic conditions of Latvia are suitable for cultivation of RCG and tall fescue and production of high yields. As compared to other alternative energy sources, RCG and tall fescue biomass may become main fuel used in Latvia counties and small businesses.

CONCLUSIONS

The application of N more than 30 kg ha^{-1} allowed to increase the dry matter yield of reed canary grass by 1.08-3.93 t ha^{-1} or by 21.05-75.44%. For tall fescue, application of N more than 30 kg ha^{-1} allowed to increase the dry matter yield by 1.94-6.94 t ha^{-1} or by 21.64-119.1%.

The highest RCG dry matter yield (9.06 t ha^{-1}) was produced with N fertilizer dose 90+90 kg ha^{-1}. The highest tall fescue dry matter yield (11.24 t ha^{-1}) was produced with N dose 60+60 kg ha^{-1}, however with bigger N dose (75+75 or 90+90 kg ha^{-1}) the tall fescue dry matter yield reduced.

The application of N more than 60 kg ha^{-1} allowed to decrease the ash content of reed canary grass by 0.25-1.22%. For tall fescue, application of N 90 kg ha^{-1}, 150 (75+75) kg ha^{-1}, 180 (90+90) kg ha^{-1} allowed to decrease the dry matter yield by 0.46%, 0.23% and 0.48% respectively.

The application of nitrogen fertilizers does not have effect on grass biomass utilisation for heat production.

The dry matter yield has high ash content, therefore it would be useful to produce pellets from grass biomass, mixing it with wood, since that would reduce ash content (one of the key problems in combustion process causing problems for heating system).

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NITROGEN CONTENT CHANGES IN WINTER WHEAT (*TRITICUM AESTIVUM* L.) DEPENDING ON FERTILIZER NORMS

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Abstract. *Field experiment with winter wheat variety 'Kranich' was carried out in the experimental field Research and Study farm "Vecauce" of the Latvia University of Agriculture during 2012 till 2014. The aim of research is to explain nitrogen dynamics in plant and in process of plant yield formation depending on nitrogen and sulphur additional fertilizer. Nitrogen was applied at the rates of 85 N kg ha^{-1}, 153 N kg ha^{-1}in two splits (85+68), 175 N kg ha^{-1} in three splits (85+60+30+18S), 180 N kg ha^{-1} in three splits (85+50+45) in 2013 according to chlorophylmeter data and 150 N kg ha^{-1} in three splits (85+50+15) in 2014 according to N-tester data, 187 N kg ha^{-1} in three splits (85+68+34). The winter wheat plants parts – leaves, stems and ears – were assessed at the BBCH 32, 51, 69 and 91. The average nitrogen concentration in leaves was 3.76 and 3.56 accordingly in 2013 and 2014. The concentration of nitrogen in leaves and stems increased till the stem elongation stage in both years, but nitrogen concentration in ears – till the end of shooting into ears stage in 2013, but in 2014 till the full ripening stage. The plant growth stage and nutrition strategy had a significant impact on the nitrogen concentration in plant leaves and stems ($p<0.05$). The meteorological conditions had factor influence (η^2) 57.5% on grain yield, but fertilizer application had influence on grain yield – 37.3%. Grain yield essentially increased till nitrogen fertilizer norm N153 in both years. The close, positive correlation was found at the 0.01 probability level between the grain yield and nitrogen concentration in leaves and stems in the stem elongation stage and between leaves and ears in the end of flowering stage, but at the 0.05 probability level between grain yield and nitrogen concentration in stems in the full ripeness stage.*

Key words: *winter wheat, nitrogen concentration, yield.*

INTRODUCTION

Nitrogen is the most frequently limiting nutrient for cereals. The determination of optimum nitrogen fertilizer rates for winter wheat is very important for economic and environmental sustainability. For high and quality grain yield obtaining, very important is increasing efficiency of fertilizer use. To increase the use of fertilizer nitrogen by crops, nitrogen should be applied according to crop plant requirements [1]. One way how to determine nitrogen optimum additional rates is by using plant tissue analyses at early growth stages [2],[3]. Close correlations have been found between uptake of plant N concentration at BBCH 32 and optimum N rates [4]. The use of diagnostic tool – chlorophylmeter is another way how to determine nitrogen status in winter wheat for split application from growth stage BBCH 32 till 51 [5]. Many researchers find close relations between leaf chlorophyll content and leaf nitrogen content [5],[6].

Sulphur is necessary for the optimal grain yield production, particularly if the grains are going to be used for the production of high quality grains [7]. The sulphur is required throughout the growth period of cereals if optimum grain quality and yield is going to be achieved. It promotes better nitrogen availability for plants. The N: S ratio ranged from 8 to 10.5:1 [8],[9]. Plant analyses at early growth stages will help determine fertilizer recommendations for winter wheat.

The aim of research is to explain nitrogen dynamics in plant and in the process of plant yield formation depending on nitrogen and sulphur additional fertilizer.

MATERIALS AND METHODS

Experimental site. Field experiments were done in the experimental field Research and Study farm "Vecauce" of the Latvia University of Agriculture during 2012 till 2014. Winter wheat variety 'Kranich' was used. The treatments were arranged in a randomized complete block design with four replications in plots of 20 m^2. The previous crop was rape seed. Soil was strongly altered by cultivation loam with pH_{KCl} = 6.6 – 7.2, content of available for plants K_2O 142-181 mg kg^{-1} and P_2O_5 114-281 mg kg^{-1}, humus content 17-23 g kg^{-1}.

Management. The sowing took place on the 21st of September 2012 and on the 12th of September 2013 with a density 450 viable kernels m^{-2}. Complex mineral fertilizer N – 15, P_2O_5 – 45, K_2O – 75 kg ha^{-1} (2012) and N – 18, P_2O_5 – 78, K_2O – 90 kg ha^{-1} (2013) were used before sowing. Nitrogen was supplied at the rates of 85 N kg ha^{-1}, 153 N kg ha^{-1}in two splits (85+68), 175 N kg ha^{-1} in three splits (85+60+30+18S), 180 N kg ha^{-1} in three splits (85+50+45) in 2013 according to chlorophylmeter data [6] and 150 N kg ha^{-1} in three splits (85+50+15) in 2014 according to N-tester data, 187 N kg ha^{-1} in three splits (85+68+34). The first dose of nitrogen was given in spring after renewal of vegetation, the second time at the end of shooting into stalk and the third time - at the end of shooting into ears. The BBCH identification key of growth stages was used [10].

During the experimental period meteorological conditions differed year by year. In 2013 vegetation renew very late – at the end of April, but May was favorable for plant development. In June air temperature exceed norm by 2.1^{o}C, but rainfall was half of norm. At the August weather was favorable for harvesting. In 2013 autumn weather conditions have been comparably good for winter crops, but in 2014 January snow fall on unfrozen land and winter wheat plants partly did not survive. Temperature in April exceeded norm and weather was warmer. April and May were characterised by lack of rainfall. Moisture in June was optimal for plant growing. At the time of harvesting weather was dryer than the norm.

Sampling, chemical and statistical analysis. The winter wheat plants were assessed at the BBCH 32, 51, 69 and 91 in each plot. Plants were taken from each sample, leaves, stems and ears separated and brought to the laboratory. Nitrogen content in leaves, stems and ears was analysed by LVS EN ISO 5983-2: 2009 method, %. Analyses were done in the Analytical Laboratory for Agronomy Research of the Latvia University of Agriculture. ANOVA and correlation analyses were used for processing the experimental data. The significance of data was determined by the Fisher's criterion with a significance level of $P \leq 0.01$ and 0.05.

RESULTS AND DISCUSSION

The average nitrogen concentration in leaves was 3.76 and 3.56 accordingly in 2013 and 2014. The concentration of nitrogen in leaves increased till the stem elongation stage in both years and maximum was obtained in N-test variant – 5.30% in 2013 and 4.25% in 2014 (Fig. 1 and 2). Similar nitrogen concentration in leaves maintained till beginning of shooting into ears in 2014, the maximum was obtained in N175 variant – 4.20%. That was observed also in other investigations [11],[12]. Depending on growth stage, nitrogen concentration in leaves increased in variants with nitrogen fertilizer till 40-73% in 2013 and till 32-57% in 2014 compared to N0 variant. The higher stability of nitrogen concentration in leaves was determined in 2014 with coefficient of variation CV% 15.3 compared to2013 (CV% 22.7). According to the F-test, growth stage and nutrition strategy had a significant impact on the nitrogen concentration in plant leaves ($p<0.05$). Nitrogen fertilizer impact in 2013 $F_{fact} = 12.7 > F_{0.05} = 3.3$ and $F_{fact} = 11.4 > F_{0.05} = 3.3$ in 2014 and growth stage impact in 2013 $F_{fact} = 44.4 > F_{0.05} = 4.1$ and $F_{fact} = 31.2 > F_{0.05} = 4.1$ in 2014 on nitrogen concentration in plant leaves.

The nitrogen concentration in stems increased till the stem elongation stage in both years but in further plant growth period decrease of nitrogen concentration in stems was observed. The maximum of nitrogen concentration was obtained in N-test variant in 2013 – 3.88% but in 2014 – 2.68%. There were very high nitrogen fertilizer application influence observed on nitrogen concentration in stems – concentration achieves 31-129% increasing compared to N0 variant in 2013, but in 2014 till 5-92% depending on growth stage and variant. The highest stability of nitrogen concentration in stems between years was observed in 2014 – CV% 64.4. The plant growth stage and nitrogen fertilizer had a significant impact on nitrogen concentration in stems ($p < 0.05$).

The average nitrogen concentration in ears was 1.69% and 1.79% accordingly in 2013 and 2014, but maximum was obtained (1.99%) in variant N153 at BBCH 69 in 2013 and 2.27% in variant N187 at BBCH 91 in 2014 (Fig. 1, 2). The nitrogen concentration in ears increased till the end of shooting into ears stage in 2013, but in 2014 till the full ripening stage. A significant impact ($p<0.05$) of nitrogen application was observed on nitrogen concentration in ears $F_{fact} = 23.7 > F_{0.05} = 3.3$ in 2013 and $F_{fact} = 6.4 > F_{0.05} = 3.3$ in 2014.

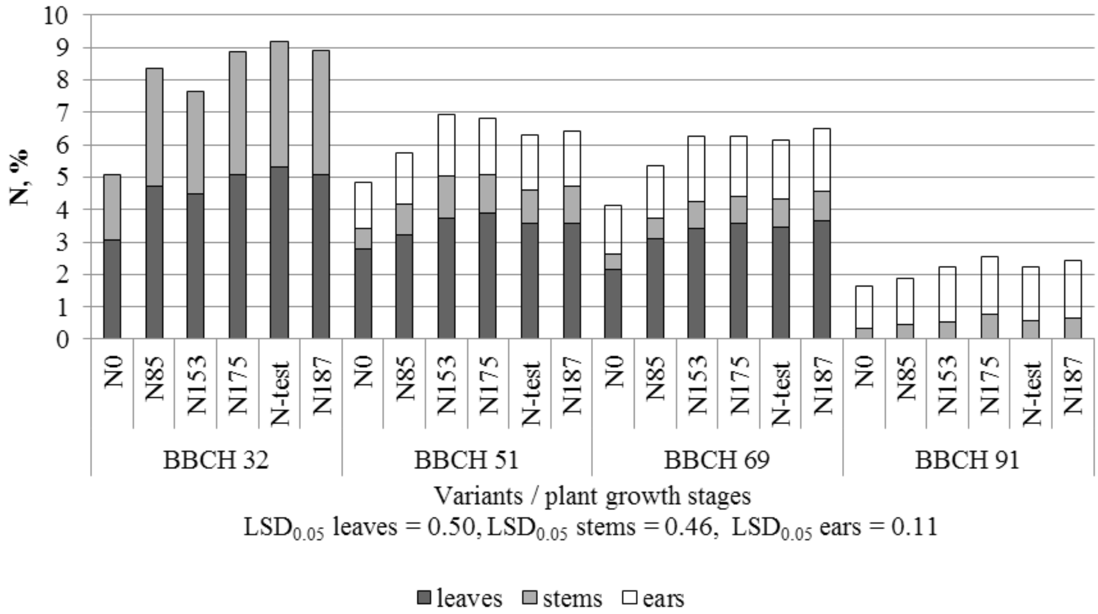

Figure 1. **Nitrogen concentration in leaves, stems and ears, 2013, %**

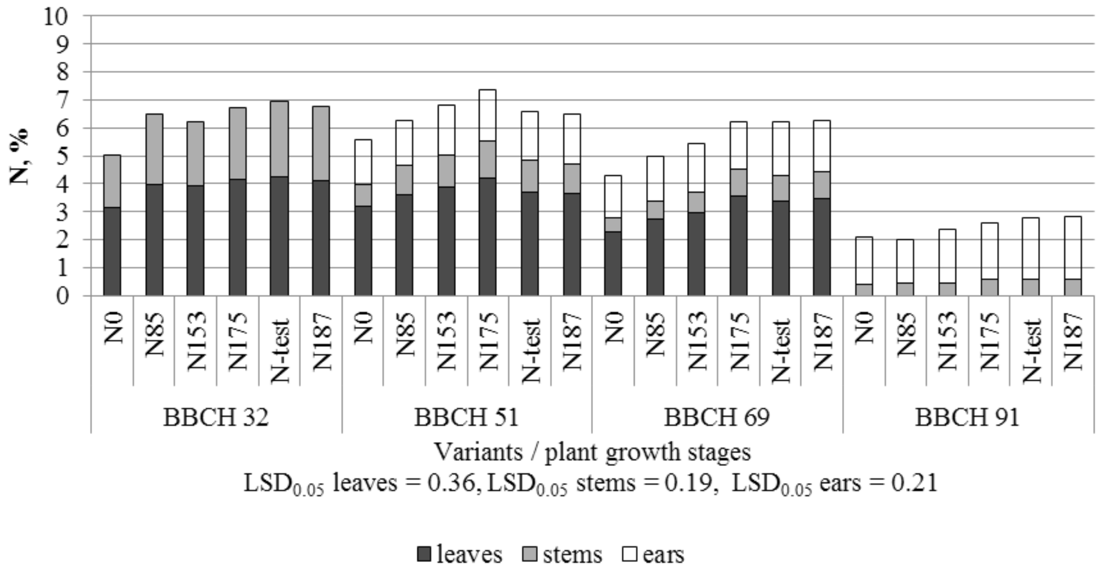

Figure 2. **Nitrogen concentration in leaves, stems and ears, 2014, %**

Table 1

Winter wheat grain yield, t ha^{-1}

Year, factor A	**N fertilizer, factor B**						**Average, LSD $_{0.05\,A}$=0.13**
	N0	**N85**	**N153**	**N175**	**N-test**	**N-187**	
2013	4.07	6.82	7.62	7.84	7.48	7.64	6.91
2014	2.79	3.31	4.67	4.86	4.77	5.20	4.27
Average, B	3.43	5.06	6.14	6.35	6.12	6.42	-
LSD $_{0.05\,B}$ = 0.23							
LSD $_{0.05\,AB}$ = 0.32							

The highest winter wheat grain yield (7.84 t ha^{-1}) was obtain in the year 2013 in variant with nitrogen fertilizer 175 kg ha^{-1} (Table 1). After 2013/2014 wintering plants become thin and in 2014 we did not get high grain yield (2.79-5.20 t ha^{-1}). The meteorological conditions had factor influence (η^2) 57.5% on grain yield but fertilizer application on grain yield – 37.3%. According to other scientist data, the grain yield had great dependence on the year – factor influence 47-93 per cent [13],[14]. It was observed that grain yield essentially increased till nitrogen fertilizer norm N153 in both years.

Close positive correlation was observed between the grain yield and nitrogen concentration in leaves and stems in the stem elongation stage and also leaves and ears in the end of flowering stage significant at the 0.01 probability level (Tab. 2). There was also close correlation between grain yield and stems in the full ripeness stage at the 0.05 probability level. Scientist Nikolic O. [15] found that N concentration in the aboveground part of the plant expressed very strong, direct, positive effects on wheat yield which mostly agree with our data.

Table 2

Correlation between winter wheat grain yield and nitrogen concentration in different plant parts, 2013-2014

Plant part	Plant growth stage			
	BBCH 32	BBCH 51	BBCH 69	BBCH 91
Leaves	0.89**	0.26	0.73**	-
Stems	0.92**	0.43	0.54	0.68*
Ears	-	0.43	0.75**	-0.03

*Significant at the 0.05 probability level
**Significant at the 0.01 probability level

CONCLUSIONS

The concentration of nitrogen in leaves and stems increased till the stem elongation stage in both years, but nitrogen concentration in ears – till the end of shooting into ears stage in 2013, but in 2014 till the full ripening stage.

The plant growth stage and nutrition strategy had a significant impact on the nitrogen concentration in plant leaves and stems ($p<0.05$).

The meteorological conditions had factor influence (η^2) 57.5% on grain yield but fertilizer application on grain yield – 37.3%. Grain yield essentially increased till nitrogen fertilizer norm N153 in both years.

The close positive correlation was found at the 0.01 probability level between the grain yield and nitrogen concentration in leaves and stems in the stem elongation stage and between leaves and ears in the end of flowering stage, but at the 0.05 probability level between grain yield and nitrogen concentration in stems in the full ripeness stage.

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THE EFFECT OF POTATO (*SOLANUM TUBEROSUM* L.) MINITUBER SIZE ON PLANT DEVELOPMENT AND SEED YIELD

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Abstract. *Many potato seed production programmes worldwide use minitubers at initial stage of seed propagation. Minitubers are pathogen-free potato seed tubers obtained from in vitro plantlets at high planting densities in greenhouses. As field performance of various sized minitubers can be rather different, it is important to know the desired minimum minituber size which is acceptable for further field multiplication at particular conditions. The study was aimed to investigate the effect of planted potato minitubers size (weight) on some plant development characteristics (emergence, canopy closure) and yield parameters (tuber number and tuber yield of seed size grade >25 mm). The effect of cultivar was analysed as well. Three cultivars of different maturity ('Monta' – early maturity, 'Prelma' – medium early and 'Mandaga' – medium late maturity) were used. Minitubers of size ranges 3-5 g, 5-10 g, 10-20 g, >20 g were planted at field of State Priekuli Plant Breeding Institute, Latvia (57°31' N, 25°34' E) in 2014. Minitubers were pre-sprouted for two weeks before planting. The planting was conducted by hand on 15 May 2014. Split-plot design in three replications with cultivar as a main plot and minituber size as sub-plot was used for the study. Minitubers of each size range were planted at 0.2 m in-row spacing and 0.7 m distance between rows. Each sub-plot comprised 48 minitubers (12 tubers × 4 rows). Only inner 20 tubers from two inner rows (10 tubers × 2 rows) were subjected to further data collecting and analysis in order to avoid the competition effect between different cultivars or between plants emerged for tubers of different size. Tubers were harvested by hand without prior haulm killing. 'Monta' was harvested 91 days after planting (DAP), 'Prelma' – 92 DAP, 'Mandaga' – 112 DAP. Emergence in days after planting to 50% emergence, to 80% and between 50 and 80% emergence was significantly determined by cultivar ($p<0.05$). No significant effect of planted tuber size was observed. Canopy closure DAP was significantly affected by planted tuber size ($p<0.05$). No significant effect of cultivar was observed on this parameter. Both cultivar and planted tuber size significantly ($p<0.05$) affected number of main stems per m^2. Harvested tuber number of size >25 mm per m^2 significantly depended on planted tuber size, whereas tuber yield >25 mm (kg m^{-2}) and mean tuber weight (g) of size grade >25 mm was significantly affected only by the cultivar ($p<0.001$). Smaller minitubers produced significantly ($p<0.05$) less progeny tubers of size >25 mm per m^2 (51 progeny tubers obtained from minitubers 3-5 g, 54 from minitubers 5-10 g, 59 from minitubers 10-20 g and 70 tubers from minitubers >20 g). As the progeny tuber derived from smaller minitubers tended to be heavier than tubers weight from bigger minitubers (statistically insignificant difference $p=0.391$), total yield of progeny tubers >25 mm kg m^{-2} did not differ significantly ($p>0.05$) between planted minituber sizes (3.48 kg tuber yield from minitubers 3-5 g, 3.59 kg from minitubers 5-10 g, 3.84 kg from minitubers 10-20 g and 4.24 kg from minitubers >20 g) This outcome can be partially explained by the fact, that planting distance between tubers remained the same among all sub-plots. Statistically significant correlations ($p<0.05$) were found between several plant development and yield parameters. Strong relationship was found between number of main stems m^{-2} and progeny tuber number >25 mm per m^2 ($r = 0.714$). The relationship between number of main stems m^{-2} and tuber yield, kg m^{-2}, was moderate ($r = 0.485$). Canopy closure DAP correlated strongly negatively with the number of main stems m^{-2} ($r = -0.767$) and progeny tuber number >25 mm per m^2 ($r = -0.756$). The relationship between canopy closure and tuber yield >25 mm, kg m^{-2} was moderately negative ($r = -0.568$). Progeny tuber number per m^2 had significant negative moderate correlation with DAP to 50%, 80% and between 50% and 80% emergence. However, no significant ($p>0.05$) relationship was found between tuber yield >25 mm, kg m^{-2} and previously mentioned emergence parameters. Further repetitive experiments must be carried out to find more certain minituber size effects on various yield parameters, i.e. progeny tuber size distribution. As well, relationships between plant development data and yield parameters should be verified in further trials.*

Key words: *Solanum tuberosum, minitubers, potato seed.*

SOIL AND WATER MANAGEMENT

EFFICIENT UTILIZATION OF NATIVE NUTRIENT SOURCES

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Abstract. *Positive phosphorus (P) and nitrogen (N) balances are common in most EU15 countries and Norway while much lower balances dominate in the more recent member states. Strongly positive balances are prevalent in intensive domestic animal production, where imported feed stuffs create a steady inflow of nutrients. N and P contained in manure stand for the largest single flows of these nutrients in the food production and consumption system, much larger than the flows in sewage. Even in Finland, not among the countries of the most intensive animal production, it has been estimated that manure P could satisfy all P fertilization need by the crops. Owing to logistic reasons, this is however not feasible in practice. Abundant use of P and N has been recognized as a problem in the European Union already for years, both from the environmental point of view and for P as an issue of wasteful utilization of a limited natural resource. This concern has resulted in projects such as Baltic Manure, and more stakeholder oriented Baltic COMPASS and Baltic Deal, and the European Sustainable Phosphorus Platform has been established. Attention has been paid to the excessive P status of many fields but still almost all countries have also fields of low P supplying capacities. These low P soils were common in Estonia, Latvia and Lithuania already in early 1990s and their proportion has likely increased during the last 25 years owing to low P use, probably resulting in yield deficit. The divergence between the countries and between fields within a country calls upon site-specific nutrient management.*

Agriculture around the Baltic Sea is not the most intensive user of plant nutrients in Europe but our Sea is highly vulnerable to eutrophication. In spite of still deficient wastewater treatment in a few major cities, agricultural land is recognized as a major source of N and P transported to the Baltic Sea. Our agriculture should focus on more efficient use of domestic nutrient sources. Substance flows such as manure, sludge, organic wastes, and different industrial by-products contain N and P and we cannot decide to produce them or not; they by and large inevitably exist. Instead, mineral fertilizers are deliberately produced, and we can reduce the production if the desired nutrients can be obtained from alternative sources in an economically feasible manner. Political decisions and new innovations are needed to facilitate a more even distribution of manure nutrients in particular.

Moreover, for certain time period, there are obvious possibilities to take the advantage of P stocks accumulated into the soil in past fertilizations with manure or mineral P; starting from medium P status, only minor or non-existent responses have been obtained with new P additions. Soil testing should be used for monitoring how long this nutrient mining is sustainable in a field concerned. In high P soils negative P balances cannot be considered non-sustainable, while that is not the case in low P soils where negative balances more rapidly result in adverse effects on yield. There is also evidence that some soils contain substantial stocks of mineral N in the subsoil and hence show exceptionally low response to N fertilization. These observations have been made on the western coast of Finland on acid sulfate soil where unfertilized potato yielded 41 t ha^{-1} with a highly negative N balance and only a 2 - t ha^{-1}yield increase upon N application.

Potassium (K) used to be the least expensive of the three major nutrients but its price has drastically increased since 2008. Fine and medium textured soils commonly have abundant K reserves. If these soils have a coarse or organic plough layer and only the topsoil is analyzed, these reserves go unnoticed and more than adequate amounts of K may be applied.

This presentation calls upon more efficient utilization of native N, P and K resources from different substance flows or those present in soil. More work is required to guarantee the fertilizer effect of these sources, and to safeguard that soil quality is not compromised by the use of waste materials. Soil testing is needed to monitor how long nutrient mining can be pursued in a sustainable manner and to recognize areas and soil types with abundant N, P and K reserves.

Key words: *nitrogen, phosphorus, potassium, nutrient balances, sustainability.*

CONTROLLED DRAINAGE AND SUB-IRRIGATION AS A METHOD TO MITIGATE ACID LOADING IN FINNISH ACID SULFATE SOILS

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Abstract. *The cultivated acid sulfate soils on the coast of Gulf of Bothnia in Western Finland are highly valued for their excellent crop yields. However, there is an urgent need to find management solutions that minimize the load of acidity and dissolved metals from these soils to watercourses due to oxidation of sulfidic materials in their subsoil. In this 4-year study, possibilities to manage the groundwater with controlled subsurface drainage (CD) and subsurface irrigation (CDI), including a vertical plastic sheet to prevent by-pass flow was investigated. The groundwater in the conventionally subsurface drained field (ND) dropped down into the sulfidic horizon for almost three months in summers. CD delayed the groundwater drop, shortening the time to less than two months. In CDI system, the groundwater could be kept above the sulfidic horizon nearly throughout the summers, thereby preventing oxidation of sulfides in the lower subsoil. The acidity of drainage waters was lowest in the CDI system. However, the effect was not substantial because the acidity was still high in all the drainage systems.*

Key words: *controlled drainage, subirrigation, acid sulfate soils, acidity.*

INTRODUCTION

Acid sulfate soils (ASS) are located worldwide mainly on coastal and floodplain areas. Their drainage, dredging, excavation and construction works cause off-site environmental hazards, e.g. deterioration of the ecologic status of aquatic ecosystems receiving acidic run-off water high in dissolved metals. These detrimental consequences are attributable to the oxidation of sulfidic materials in the subsoil horizons of ASS, which results in the formation of sulfuric acid dissolving toxic metals from soil. Once initiated the negative impacts may last for a long time. Furthermore the global climate change is assumed to bring along extreme droughts which might lower the groundwater table facilitating the penetration of oxygen deeper into the subsoil and resulting in increased hazards.

In Europe the largest ASS areas in agricultural use are located on the coasts of the Baltic Sea [1]. Exclusively in Finland 7% of farmland is estimated to be ASS fields and they have been drained for cultivation without properly knowing their negative consequences to the environment. These fields are highly valued for their excellent crop yields. However, since chronic deterioration of aquatic ecosystems due to AS soils has been revealed, practical water protection measures are urgently needed in order to cultivate these fields in a sustainable manner.

MATERIALS AND METHODS

The experimental field was located in Söderfjärden on the western coast of the Gulf of Bothnia in Finland (Fig. 1). The sulfidic sediments starting at the depth of 1.5 m were formed during the Litorina Stage about 8000-3000 BP. The field was divided into three differently managed sections, which were drained with subsurface pipes at a depth of 1.1 m in a uniform manner (Fig. 2). The water management practices included: 1) normal subsurface drainage (ND), 2) controlled drainage (CD) and 3) sub-irrigation (CDI). The water regulation depth was set up at 0.5 m below the soil surface by control wells in summers and water was pumped into the drains of the sub-irrigated section during droughts. Lateral flow of groundwater between sections and seepage to the main drain was prevented by vertical plastic sheet which was installed at the depth of 1.8 m [2].

Three perforated groundwater pipes were installed in each water management treatment to the depth of 2.5 m. A groundwater logger (EHP-QMS) was installed in one pipe of each treatment and the two other pipes were manually monitored twice a week or on a monthly basis. In the present study the groundwater depths (GW, m) are the depths from soil surface. The acidity of discharge water (mmol dm^{-3}) was determined according to the standard (SFS 3005) by titrating with NaOH to a potentiometric end point of pH 8.3.

RESULTS AND DISCUSSION

The plastic sheet was able to efficiently prevent lateral flow and seepage so that the water table stayed above the potentially acid sulfate (PASS) horizon throughout the summers in the sub-irrigated section but in the sections where controlled drainage without pumping was applied water table dropped into the PASS horizon for 35 days on average and in the normally drained sections for 93 days during summers 2011-2014 (Fig. 3). This difference between CD and CDI indicated that seepage can be efficiently prevented by plastic sheet. Furthermore, because its installation was found to be practicable [3], the method is already put into operation by local farmers.

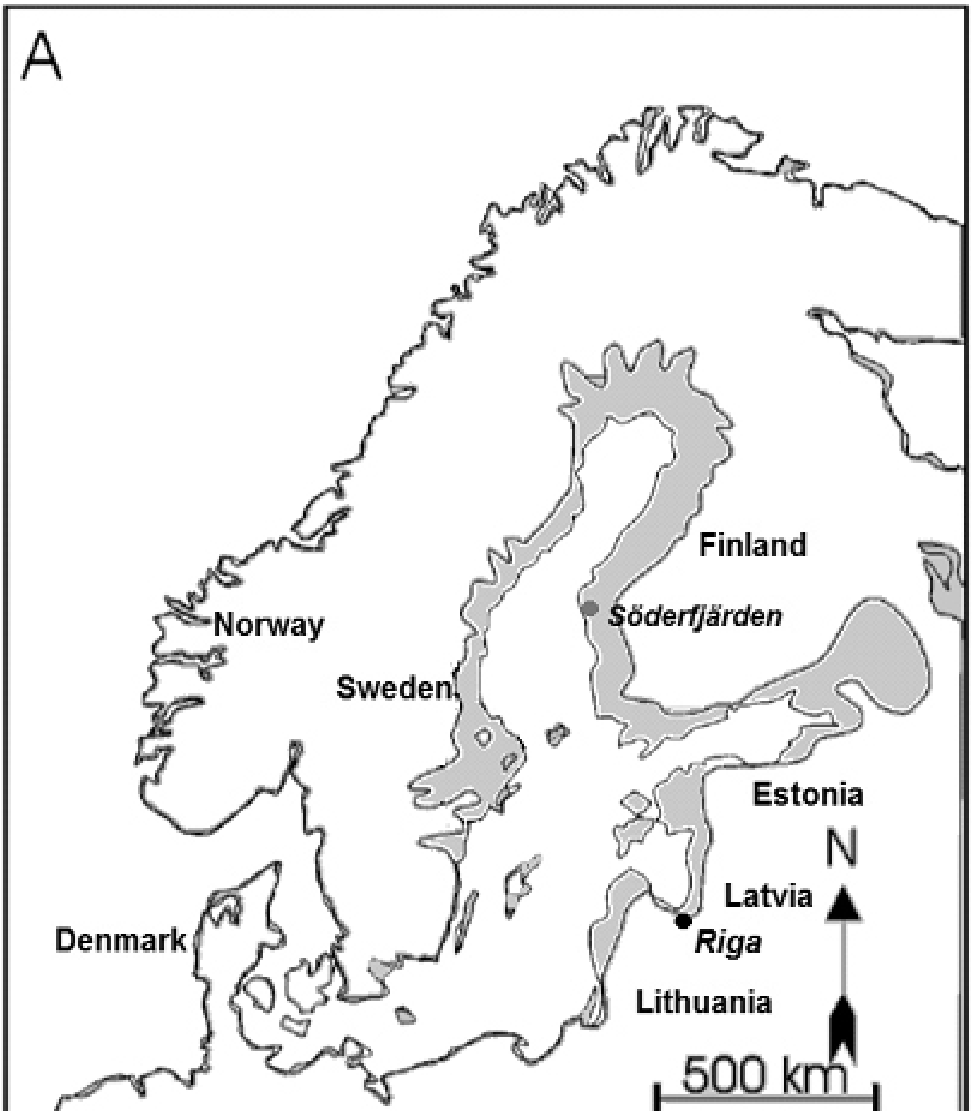

Figure 1. **The location of the Söderfjärden experimental field. The present land areas covered by the Litorina Sea on the coast of the Baltic Sea are shaded.**

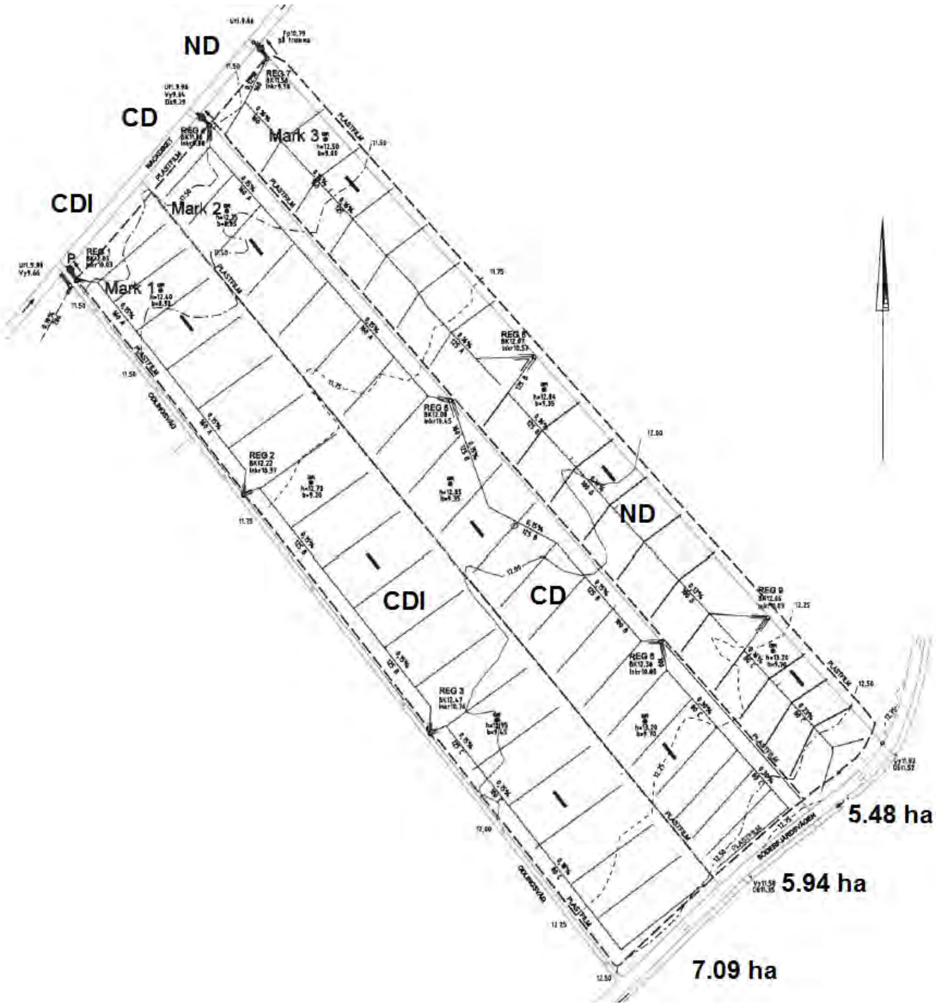

Figure 2. **The layout of the drainage systems in experimental field [3].**

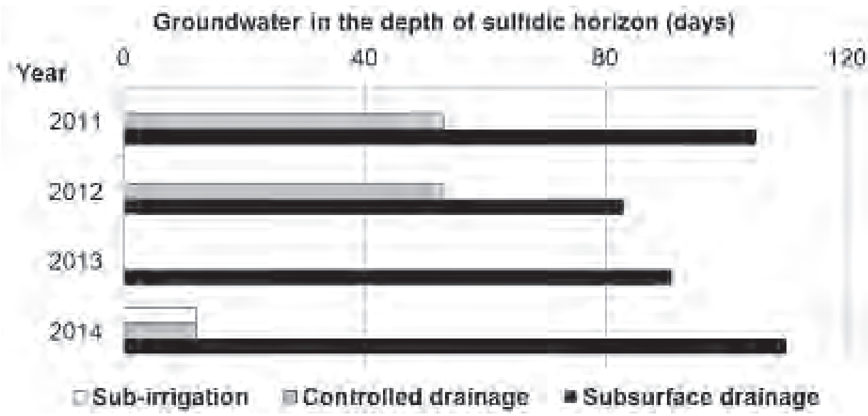

Figure 3. **The number of days when groundwater was in the sulfidic horizons in the different drainage systems.**

The acidity of drainage water decreased in all treatments in the course of the experiment but the decrease was less marked than assumed on the basis of successful groundwater control (Fig. 4). However, in the drainage water of the sub-irrigated section (CDI), the acidity of the drainage water (mean = 2.3 ±0.07 mmol dm^{-3}) was significantly lower than those of the normally drained (ND) section (2.8±0.05 mmol dm^{-3}; $P<0.001$, n = 38) indicating that water quality can be at least slightly improved by sub-irrigation. The acidity was generally lower in the sub-irrigated (CDI) than in the controlled drainage (CD) section, but the differences were not statistically significant.

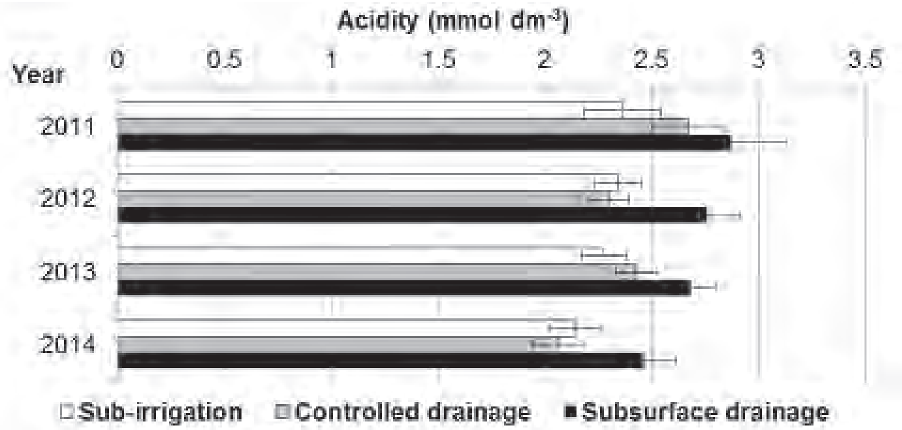

Figure 4. **The annual mean acidity of drainage water in the different drainage systems. The error bars are the standard errors of the means.**

In the sub-irrigated treatment the lowest number of days that the groundwater was in the sulfidic horizon evidently resulted in the lowest acidity in the drainage waters. That is also in agreement with the lowest total actual acidity values determined in the subsoil of this treatment after a 3-year experimental period [4]. One reason for moderate decrease in acidity in sub-irrigated and controlled drainage treatments might be the retained acidity, contained in jarosite and schwertmannite, which release acidity when soil pH rises [5].

CONCLUSIONS

We concluded that the plastic sheet was efficient in preventing seepage from cultivated and by controlled drainage and sub-irrigation the acidity leaching from cultivated ASS fields can be at least slightly mitigated. However, the effect was not substantial because the acidity was still high in all the drainage systems.

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VISUAL DRAINAGE ASSESSMENT: LAND DRAINAGE DESIGN ON THE FARM

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Abstract. *Land drainage design is based on the full characterisation of soil physical and hydraulic properties and the input of this data into standard steady-state drainage design equations to elucidate appropriate drain spacing and depth. Although in-situ and ex-situ methods for quantifying soil physical properties are long established, they are often disregarded by practitioners in the field due to time and monetary constraints. Instead, generic designs based on local knowledge/experience are used. Such generic approaches can result in poorly designed and ineffective drainage systems. There is a need for a more sustainable drainage design approach which involves farmers and contractors from start to finish. This type of in-situ site-specific drainage design must not rely on ex-situ soil physical and hydraulic testing. The new design method presented is called visual drainage assessment (VDA). The objectives of the current study were to compare designs developed using a) the VDA methodology criterion b) optimal criterion and c) generic criterion for six dairy farms in south-west Ireland. For the VDA methodology nine indicators (water seepage, texture (sand/silt/clay %), absence or presence of pan layers, structure, porosity, consistence, stone content, colour/mottling and root development) were chosen to permit inference of soil permeability or to identify characteristics that inhibit or promote particular drainage techniques. Multiple soil test pits were excavated on each site and examined with respect to each of the indicators. A classification of each was provided in relation to depth below ground level. Discrete soil horizons in each profile were delineated in light of distinctions between indicators with increasing depth. Then, using the indicators, these horizons were classified as highly, moderately or poorly permeable. Groundwater drainage systems were prescribed if highly permeable layers, which can be exploited by field drains, were overlain by moderately permeable layers, which could facilitate percolation of surface water through the profile. Shallow drainage systems incorporating disruption techniques were prescribed where poorly permeable profiles were uncovered. To establish optimal drainage design depth and spacing (assuming a design discharge capacity of 12 mm/day and mid-drain watertable depth of 0.45 m for optimal design scenarios, texture and saturated hydraulic conductivity (k_s) (measure of permeability) were determined in the laboratory using horizon specific soil samples, which were subsequently used as inputs into standard steady-state drainage design equations. Also an arbitrary generic drainage system (0.8 m deep drains at 15 m spacing) was prescribed for each site regardless of site conditions or soil characteristics. The spacing and depth achieved using the three methods were compared for each site in terms of discharge (mm/day) and watertable control (mid-drain watertable depth, m) capacity. All VDA designs were similar to the optimal design at each site in terms of drain depth and spacing. Drainage discharge capacity from the VDA designs ranged from 10.7 to 15.6 mm/day, while mid-drain watertable depths ranged from of 0.29 m to 0.73 m. The generic systems were shown to be wholly inadequate with drainage discharge capacities of 0.0 to 1.0 mm/day and estimated mid-drain watertable depth at all sites of 0.0 m. Therefore the VDA methodology described provides an alternative method of approaching land drainage design where the permeability of the soil is not measured but interpreted by visually and manually examining the soil profile. The estimated performance of drainage systems designed by VDA was much better than that attainable by generic design and was similar to that achievable by the optimal design. The method needs to be developed further and validated for a non-expert audience over a range of site and soil conditions.*

Key words: *VSA, visual, drainage design, user-friendly, site-specific.*

ANALYSING PERFORMANCE AND CONTRIBUTING AREAS OF A SUBSURFACE DRAINAGE SYSTEM WITH A HYDROLOGICAL MODEL

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Abstract. *Subsurface drains are imperative in cultivated Nordic clayey soils to manage water balance especially during wet autumns and spring snow melt periods. The performance of a subsurface drainage system can decrease with time due to compaction of the soil, clogging of the pipes, and decrease of hydraulic conductivity in the drain trenches. The efficiency of an existing system can be improved by reinstalling the drainage system, by installing supplementary drains in wet problem areas or by attempting to clean the existing drain pipes. The resulting spatially heterogeneous drainage system complicates the estimation of the water balance, water contributing areas and nutrient loads in the field. Also, annual variations in the hydro-meteorological conditions can effectively hide changes in the performance of the subsurface drains. We present a computational method, in which we use the FLUSH model in conjunction with data to estimate the relative performance of different parts of a subsurface drainage system installed in a field area. FLUSH is a three-dimensional hydrological model developed for structured soils such as clays in Nordic conditions. Model input data, including precipitation, potential evapotranspiration, air temperature, short and long wave radiation, humidity and wind speed, are given as hourly time series. In the simulations, the model applies varying time step lengths up to the used data time step (one hour). Simulation results are comprised of hourly surface and drainage runoff, evapotranspiration and groundwater outflow series. The model can also save time series of point like variables such as soil moisture, groundwater table depth and soil temperature in selected locations. FLUSH is able to simulate heterogeneous subsurface drainage systems with a varying drain spacing and depth due to the spatially distributed nature of the model. A sensitivity analysis is used in the study to derive a parametrisation for the distributed drainage system. The method is used to study the subsurface drainage system in the clayey Hovi agricultural monitoring site (12 ha, slope 2.8%) in southern Finland and to assess the efficiency of different parts of the system installed in 1971 (drainage spacing 22 m, installation depth 1 m), 1995 (spacing 14 m, depth 0.7 m) and 2005 (spacing 15 m, depth 1 m). The lateral drains are plastic pipes with a diameter of 0.05-0.065 m, and the collector drains are steel and plastic pipes with a diameter of 0.08-0.09 m. Gravel was used as an envelope material. The undocumented supplementary drains installed in 1995 and found in our analysis caused uncertainties and errors into the estimation of the water balance components (tillage layer and subsurface drainage runoff) after 1995 in the site. Intermittent hourly data on drainage and total runoff were available from the field, and data from 2010-2011 was used for model calibration and 2012 for validation. We were able to quantify the components of the water balance (% of precipitation) including tillage layer runoff (< 10%, surface runoff 4-6%), drainage runoff (32-34%), evapotranspiration (46-53%) and groundwater outflow (5%) in the field area with the model. The Nash-Sutcliffe model efficiency coefficients for total runoff (sum of tillage layer and drainage runoff results) for the whole year were 0.43 (2010), 0.70 (2011) and 0.18 (2012). Corrected precipitation during the study years was 577-678 mm a*$^{-1}$*. The relative contribution of the original drainage system (1971) to drain runoff was lower compared to the fraction from the newer parts (1995 and 2005), which suggested that the performance of the original system had decreased. According to the simulations, influx of groundwater from the surrounding terrain affected the hydrology of the field during moist periods (late autumn and spring snow melt periods). A simulation scenario was conducted to test the effect of groundwater inflow to the field area from the surrounding terrain. Our study shows that distributed hydrological models provide the tools to close the field-scale water balance, quantify all key water flux components at field boundaries, and evaluate the efficiency of multiple drainage systems. This quantification provides a promising basis for estimating nutrient loads.*

Key words: *FLUSH model; clay; subsurface drain; water balance; subsurface drain performance.*

SIMULATION OF WATER FLOW TO SUBSURFACE DRAINS CONSTRUCTED WITH TRENCHLESS AND TRENCH INSTALLATION METHODS

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Abstract. *In southern Finland, most cultivated clay soils are subsurface drained to improve drainage capacity especially during spring snowmelt and autumn heavy rains. Due to the low hydraulic conductivity of clay soil, more permeable drain trenches can have a large impact on infiltration and water flow to the subsurface drains. The objective was to study how drain trench installation method (trenchless – TR or trench installation – TI) and use of vertical gravel drains (TI only) affect the generation of drain discharge. The comparisons were realised with a computational model tested against field data. The applied three dimensional (3-D) hydrological FLUSH model is specifically developed for simulation of water flow in structured soils in Nordic conditions. The model describes water movement in both soil matrix and macropores with the Richards equation. The model was applied to clayey field sections (section A: 2.9 ha and C: 1.7 ha, slopes < 1%) with separately monitored subsurface drainage systems (A: spacing 6 m and C: 8 m) located in southern Finland (in Jokioinen). We used two-dimensional (2-D) and 3-D computation grids to describe water movement in the TR (section A) and TI (section C) trenches, respectively, and the surrounding soil. In the TI trench simulations, the 3-D computational grid (area 4×3.5 m^2) was laterally bounded by 1) the drain line, 2) the midpoint between the investigated line and the adjacent line, 3) a vertical gravel drain in the drain trench and 4) the midpoint between two vertical gravel drains (7 m spacing). In the TR simulations, the 2-D grid (cross-section 3 m) was delimited by 1) the drain line and 2) the midpoint between the investigated line and the adjacent line. The depth of the grid (1.5 m) was extended only slightly below the subsurface drain depth (A: 0.9 m and C: 1.0 m), because macroporous soil with high conductivity was assumed not to reach soil beneath the drains. Horizontal cell dimensions were 0.025×0.025 m^2 and the maximum vertical cell depth was 0.05 m in the grid. The model was calibrated and validated against drain discharge, groundwater table depth and soil moisture data from autumn and spring periods recorded in the field sections during 2007-2014. We were able to assess the roles of the drain trench backfill material, tillage layer soil and surrounding soil on water movement in the soil profile. In the simulation using the Jokioinen soil type, the vertical gravel drains appeared to have only a minor effect on drain discharge. A sensitivity analysis was carried out to provide information about the effects of the key parameters on infiltration and water flow to subsurface drains. The results from the small scale simulations are used to improve the description of the drain trenches in field scale 3-D simulations.*

Key words: *Subsurface drainage, FLUSH model, clay soils, drain trench.*

EFFECTS OF LAND-USE, TOPOGRAPHY AND HYDROLOGICAL VARIATION ON SEDIMENT LOADS IN CLAYEY SUBSURFACE DRAINED AGRICULTURAL FIELDS

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Abstract. *Arable areas constitute a major source of environmental loading to surface waters in the Baltic Sea catchment area. Soil erosion and resulting transport of sediment from the fields carry large amounts of suspended nutrients and other substances to the surface water bodies. Designing effective water protection measures is a challenging task, since the diffuse loads to surface waters originate from areas with spatially and temporally varying characteristics, such as agricultural land-use, hydrological conditions, soil type and topography. Water protection planning calls for improved understanding of the effects of these factors on field-scale erosion and sediment transport processes. The objective of this study was to evaluate how the key areal characteristics control long-term erosion and sediment transport on the basis of an application of the process-based 3D FLUSH model. Hydrological and sediment load data were available from two clayey subsurface drained agricultural fields (sizes 5.7 and 4.7 ha) that were monitored throughout 7 studied years (2008-2014). The agricultural land-use (annual crop, grassland and pasture) of the fields varied during the years, and the two fields had similar drainage systems and soil properties, but different topographic features (slope 1% and 5%). The erosion and sediment transport simulations were built on earlier model parameterisation of the site hydrological conditions by Turunen et al. (2015), who calibrated and validated FLUSH against drain discharge, tillage layer runoff and groundwater table levels. In this study the erosion and sediment transport submodel of FLUSH was tested in continuous long-term simulations against the measured cumulative sediment loads via subsurface drain discharge and tillage layer runoff from the two fields. The simulations allowed separate quantification of the hydrology-induced effects on annual sediment loads and land-use-induced effects. The preliminary results suggested that the amount of sediment transported from grasslands was only slightly lower compared to crop-cultivated areas. Compared to crop-cultivation, freshly established pasture-land decreased the amount of annual sediment loading more than grasslands. However, annual loading from the pasture-land seemed to increase throughout the studied years. The annual sediment loads were systematically clearly higher in the steeper field, as expected. The simulations and high measured annual variation in the sediment loads from the cultivated fields indicated that hydrological variation (e.g. annual precipitation and snowmelt patterns) mostly controlled the generation of annual loading. Land-use was noted to have a clear but less important impact on the annual loads. Also the slope-induced impact on sediment loads was lower than the hydrology-induced impact in the studied conditions. Annually the largest share of sediment was observed to be transported to the adjacent stream via the subsurface drains. This should be taken into account when designing water protection measures. Though tillage layer runoff measurements during several spring snowmelt periods involved considerable amount of uncertainty, most of the sediment load seemed to be transported from the field via the subsurface drains also during spring snowmelt events.*

Key words: *Erosion, sediment, agricultural land-use, subsurface drainage, 3D modelling.*

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SUBSURFACE DRAINAGE RUNOFF BEHAVIOUR IN NORWAY

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Abstract. *This paper presents results of an analysis carried out on subsurface drainage discharge measurements from small field scale catchments located in Norway. The analysis shows that subsurface runoff constitutes a major part of the total runoff. The major share of the yearly runoff occurs after the growing season from September-April. Runoff generation occurs fast with 90% occurring within 50 and 150 days for Vandsemb and Øvre Time respectively. The fast generation is also an indication that nutrient loss occurs during a limited number of days of the year. Large diurnal variations in discharge occur which is an indication that the subsurface drainage system function satisfactorily, reacting fast to input from precipitation. The large diurnal variation in discharge also leads to significant differences in specific discharge values, depending on the time resolution used to calculate. These large differences can also have implications for the dimensioning of hydro-technical implementations in agricultural dominated catchments*

Key words: *drainage, runoff, generation, seasonality, flashiness.*

INTRODUCTION

In many countries the natural drainage condition of the soil is not enough to provide optimal growing conditions for agricultural crops in which case artificial drainage is necessary. Excess water then can leave the soil profile through a system of perforated pipes, often installed at regular spacings and a certain depth below the soil surface. Another advantage of a well-functioning drainage system is its positive effect on timely tillage operations during both spring and autumn. Several studies have shown the positive effects of drainage systems on yield. An increase in spacing can lead to a reduction in the relative yield [1]. A study showed that the impacts of excess water and planting delay on yield reduction increased with wider drain spacing [2]. A major part of the agricultural land in Norway has been provided with subsurface drainage systems. The design is based on field studies in South-Eastern Norway studying the effects of spacing on trafficability, land preparation and tillage operations during both spring and autumn. The results lead to recommendations for drain spacing [3]. There exist well documented empirical relationships, describing drain spacing as a function of a design discharge rate, groundwater level and soil physical parameters, based on either a steady or non-steady state approach [4]-[6]. Often a steady state approach is used in designing the drain spacing. However, under conditions with climate change and a predicted increase in precipitation the non-steady state approach might be applied, setting requirements to the recession time of the ground water table. When designing drainage systems, different aspects have to be considered. Subsurface drainage is a major contributor in the total runoff, indicating this also to be a major pathway for nitrogen [7]. A comparative analysis of nutrient loss through surface and subsurface runoff at field scale catchments in Norway showed that the share of total field scale nitrogen loss through the artificial drainage system was more than 80% [8]. Drainage design influences the nitrogen transport, with an increase in nitrogen loss occurring when reducing the drain spacing [9],[10]. As subsurface drainage has an important effect of the soil moisture condition it also has an effect on nitrous gas emissions [11]. Climate change predictions for Norway indicate an increase in precipitation, especially after the growing season and uncertainty exists as to how to design drainage systems taking into consideration the aforementioned effects of subsurface drainage systems. In addition to an increase in precipitation, also more episodes with higher rainfall intensities will occur [12]. An understanding of how present day drainage systems function is important in this respect. In this paper the results of an analysis on subsurface drainage runoff in three small field scale catchments in Norway is presents.

MATERIALS AND METHODS

Three small field scale catchments, Bye, Vandsemb and Øvre-Time respectively, were established as part of the Norwegian Environmental Monitoring Programme (JOVA) [13]. Bye is located approximately 150 km north of Oslo. Vandsemb is located approximately 50 km north east of Oslo. Øvre Time is located in south west Norway in the vicinity of Stavanger town. The main characteristics of the field scale catchments are presented in Table 1. Øvre-Time and Vandsemb are located within the JOVA catchments Time and Mørdre respectively while Bye is located close to the JOVA catchment Kolstad. There are considerable differences in the long term mean annual temperature, with Bye and Vandsemb located in Eastern Norway, having the lowest temperatures (Table 1). The highest mean annual precipitation is recorded at the Øvre–Time field scale catchment. In both Bye and Vandsemb, surface and subsurface drainage runoff was measured, while at Øvre-Time only subsurface runoff was measured. In this article the main focus will be on the behaviour of subsurface drainage runoff. The discharge is measured using a discharge measurement structure in combination with a data logger. Different time resolutions are used between the stations varying from recording the discharge every 10 minutes (Vandsemb, Øvre Time) to hourly recording (Bye). In this paper hourly discharge values are used.

Table 1

Field scale catchment characteristics

	Øvre Time	**Vandsemb**	**Bye**
Size	2.4 ha	6.5[1]/5[2] ha	4 ha
Temperature[3]	7.1°C	4.0°C	3.6°C
Precipitation[4]	1189 mm	665 mm	585 mm
El. range[5], (m a.s.l.)	65-75	157-166	130-155
Slope	Gently sloping	2% (p), 10-16% (r)	10%
Deposits	Glacial till	Glaciolacustrine, marine	Glacial till
Texture topsoil	Loamy medium sand	Silt loam, silt, silty clay loam	Loam
Drain depth	0.8-1.00	0.8 m	1 m
Drain distance	6 m	8 m	10 m
Main crops	Grass ley	Spring cereals	Spr. cereals/potato
Measurement period	1997-2013	1992-2005	1992-2013

[1] – subsurface drainage runoff, [2] – surface runoff , [3] – long term annual precipitation,
[4] – long term annual precipitation, [5] – elevation range in meters above sea level

RESULTS AND DISCUSSIONS

Runoff

Measurements at Vandsemb and Bye showed that subsurface drainage is the major contributor to total runoff (Figure 1). For Vandsemb, on average the yearly subsurface runoff is 208 mm, approximately twice the yearly surface runoff. For the Bye the yearly subsurface runoff is more than 10 times larger than the yearly surface runoff. The main reason for not measuring surface runoff at Øvre Time is due to the fact that this rarely occurs, mainly due to the dominating soil types, climatological conditions with less frozen soils and ley agricultural practices. The average annual subsurface runoff for Bye and Vandsemb is 155 and 208 mm respectively, which is small compared to the Øvre Time field scale catchment, having 712 mm average yearly runoff (Table 2). A reason for the difference between Øvre Time and Vandsemb/ Bye is due to the amount of precipitation this being significantly higher for the Øvre Time field scale catchment (Table 1).

Seasonality

Seasonality is the relative contribution of different seasons in the total annual subsurface runoff. In this case spring is represented by the months of March and April; summer by the months of May-August; autumn by the months of September-November and winter by the months of December-February. For Vandsemb and Øvre Time the runoff contribution during summer the season is lowest while for Bye this is the autumn period. However for all three field scale catchments the major part of runoff occurs after the growing season during the period from September-April. This also might be an indication that the major nitrogen transport occurs during this period as subsurface drainage systems are important in transporting nutrients to open water systems. Different research confirmed this showing the highest nitrate runoff through subsurface drains occurred during the off season [14]-[16].

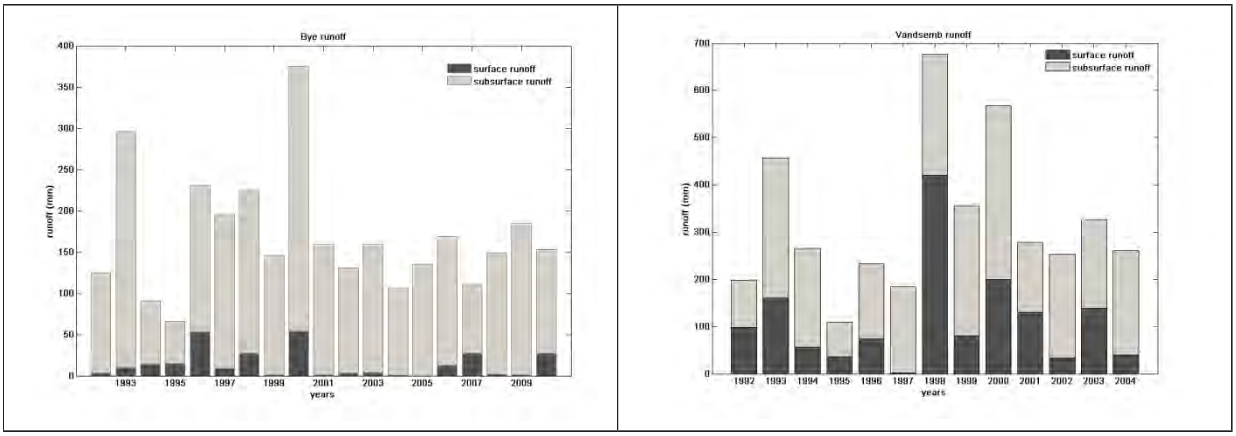

Figure 1. **Surface and subsurface runoff at Bye (left) and Vandsemb small fields (right)**

Table 2

Average yearly runoff and seasonality in field scale catchments

Catchment	Year (mm)	Seasonality (%) sum	aut	win	spr	Days to generate 50/90% of yearly runoff	Flashiness index day	hour
Vandsemb	208	16	27	25	32	16/51	0.64	1.50
Bye	155	21	30	10	39	14/69	0.36	0.77
Øvre-Time	712	10	39	37	14	42/150	0.48	2.03

Runoff generation

As runoff processes are the driving force behind nutrient- and soil loss processes, it is of interest to have knowledge about the amount of days during a year runoff is occurring, as such information may be relevant in the design of monitoring programmes. An analysis of runoff generation showed that only few days are needed to generate 50 and 90% of the yearly runoff (Table 2, Figure 2). In this case also the surface runoff was included in the analysis of runoff generation, however only visualised in Figure 2. Considerable differences in runoff time exist between the field scale catchments but also between surface and subsurface runoff generation. Only very few days are needed to generate the total yearly amount of surface runoff as measured at Vandsemb and Bye, the main reason for this being due to the fact that the yearly surface runoff is considerably less compared to the yearly subsurface runoff.

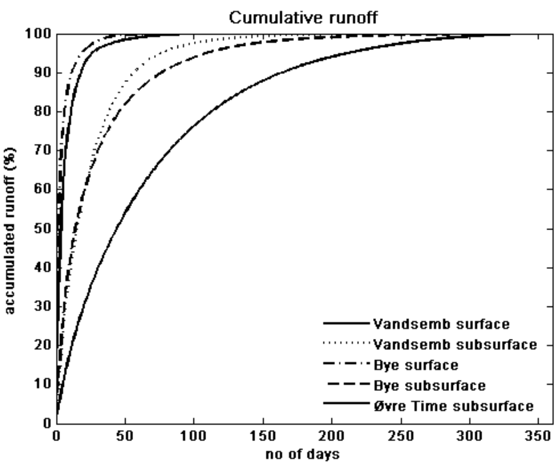

Figure 2. **Runoff generation as a function of time**

The fact that surface runoff occurs only during a limited number of days compared to subsurface runoff, is also an indication of the relative importance of subsurface runoff in the total runoff at larger agricultural dominated catchment outlets [7]. The fast generation of runoff in small agricultural dominated catchments implies also that nutrient and loss of suspended sediments occurs during a limited number of days, which definitely must have implications for water sampling routines.

Flasiness index

Very large diurnal variations in discharge occur in small agricultural catchments [17]. The degree of this variation can be described by a so-called flashiness index (*eq. 1*) [18]. Flashiness index gives an indication how quickly flow changes from one condition to another. The flashiness index is often calculated on a yearly basis as the total path length of flow divided by the sum of average daily discharge, the flow path in this case being equal to the sum of the difference between the daily discharge values as

$$FI = \frac{\sum_{i=1}^{n} |q_i - q_{i-1}|}{\sum_{i=1}^{n} q_i} \qquad (1)$$

where q_i and q_{i-1} are the average daily discharge values on day (i) and day(i-1). To obtain the FI based on hourly discharge values, the flow path is calculated as the sum of the difference between the hourly discharge values. There are differences in FI between the field scale catchments, but more important, there is a considerable increase in FI when using hourly discharge values (Table 2) which is an indication that significant diurnal variations in discharge occur. The high FI also implies that the subsurface drainage system functions satisfactorily, reacting fast to input from precipitation. As the discharge is directly related to the groundwater level this also means that an original high groundwater level, caused by precipitation, will show a fast recession. This was confirmed by measurements of the groundwater level midway between drains in the Øvre Time field scale catchment, carried out during a two years period. The ground water level showed a very fast recession after an instantaneous increase because of precipitation. A main conclusion of that study was that the existing subsurface drainage system was able to deal with precipitation as predicted by climate change [19].

Specific discharge

The very large diurnal variation in discharge also has a significant effect on the specific discharge values, depending on the time resolution used in the calculation. There is a considerable difference in the specific discharge depending on the time resolution used, for Øvre Time the difference being more than a factor two (Table 3). There is a considerable variation between years, exemplified by the large coefficient of variation for the individual field scale catchments (Table 3 and Figure 3). Øvre Time has the highest specific discharge, equal to 9.95 and 4.58 l s^{-1} ha^{-1} respectively when using hourly and average daily discharge values.

Table 3

Average maximum specific discharge based on hourly and average daily discharge values during observation period

	hourly discharge (l s^{-1} ha^{-1})			**daily discharge (l s^{-1} ha^{-1})**		
	mean	max	cv (%)	mean	max	cv (%)
Bye subsurface	1.57	2.38	41	1.14	1.95	42
Vandsemb subsurface	1.63	2.34	22	1.23	1.78	18
Øvre Time	4.50	9.95	39	2.07	4.58	37

A main reason for this high specific discharge at Øvre-Time is probably due to a combination of drain spacing being the narrowest, precipitation being the highest and the dominating soil type, with a higher hydraulic conductivity. The large differences in specific discharge values can have implications for the dimensioning of hydro-technical implementations in agricultural dominated catchments.

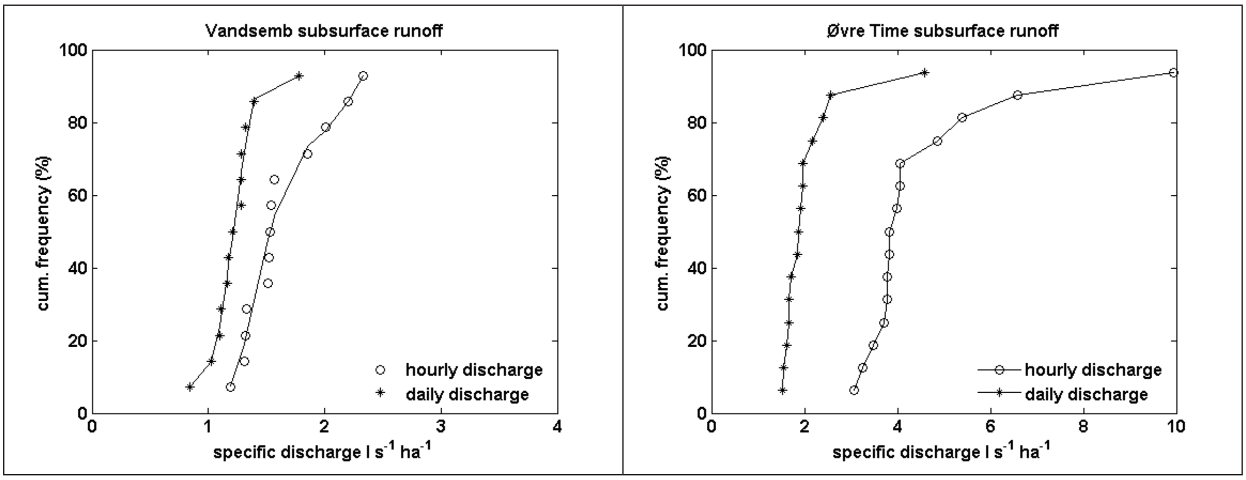

Figure 3. **Specific discharge values for subsurface drainage runoff at Vandsemb and Øvre Time field scale catchments**

CONCLUSIONS

The measurements show that the major share of drainage runoff occurs after the growing season. Large differences in specific discharge occur when using hourly or daily discharge values, implying that in dimensioning hydro-technical implementations in the agricultural landscape, hourly discharge values should be considered. The analyses results also indicate that there are large diurnal variations in subsurface drainage runoff, which is an indication that the system functions properly, being able to quickly react to input from precipitation, and hence enhancing a fast drawdown of the groundwater table. In future design of drainage systems, under conditions with a changing climate and increase in precipitation, a non-steady state approach might be considered as a fast drawdown of the water table is important with respect to the soil moisture content and hence trafficability and workability.

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TOWARDS A NEW SOIL AWARENESS – EDUCATIONAL TOOLS FOR USE IN PRIMARY SCHOOL

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Abstract. *The Earth is facing serious trouble due to human-induced soil degradation. Does the notion we have of soil influence the way we treat it?*
To explore peoples' notions of soil, workshops involving 170 individuals (age 8-70) in 9 various groups from 3 Western countries were conducted. In order to capture what might be embedded or intuitive knowledge or images of soil, participants were asked to draw their impression of soil. The drawings varied from explicit anthropocentric focus to symbolic or holistic expressions. Viewed together, the drawings revealed an enormous variety of aspects connected to soil. The variety of elements opened up discussions on soil health issues and contributed to broaden the understanding of soils' diverse and very complex properties. The workshops also revealed a serious lack of understanding of vital soil functions. Extended soil awareness is therefore badly needed. Useful educational programmes on soil already exist, but programmes explicitly emphasising the notion of soil as a living, life-giving substance and based on a holistic view, need to be developed. Such programmes must also stress that taking care of soil is a common responsibility.

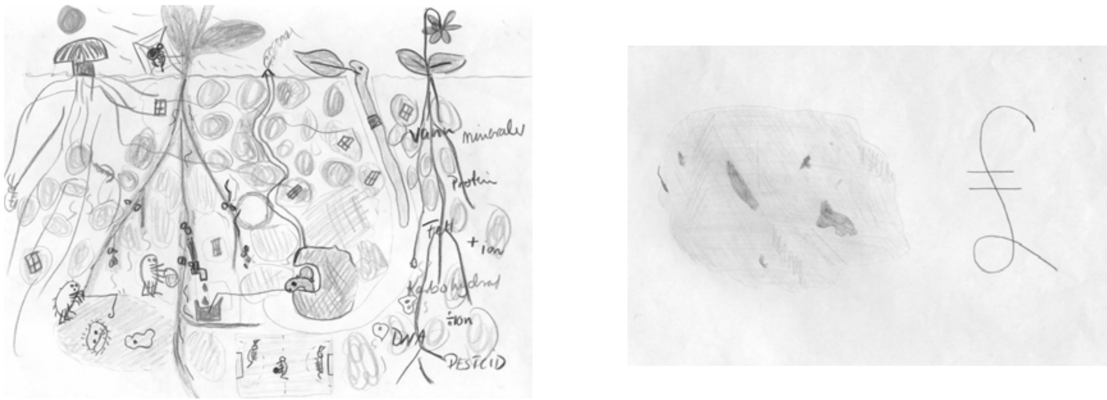

Figure. ***"Soil is a living community" and "Soil is the farmer's capital". How two participants drew and explained their images of soil when exploring their personal "notion of soil".***

The workshop, in addition to other "living soil" activities, has been further developed and used in Norwegian schools in mid Norway as an introduction to the theme of sustainable soil management.

Key words: *Soil awareness, soil notion, soil education.*

HISTOSOLS IN LATVIA AND WRB SOIL CLASSIFICATION

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Abstract. *Organic soils (Histosols according to the World Reference Base for Soil Resources – WRB) are important source for CO_2 emissions if used as a cropland. National System for Greenhouse gas (GHG) inventory, evaluation and reporting requires detailed information about the soil cover within the area of concern, e.g. Latvia agricultural land. Inside the country soil information is available in the form of national (genetic oriented) soil classification however international institutions requires the use of WRB. Fundamental differences in soil classification systems make difficulties for direct comparison of soil taxa. Some solutions for overcoming of this problem are proposed and discussed here. Technically it will be possible after digitizing all soil maps for agricultural land at the scale 1:10000 and developing relevant algorithm for transition from one soil classification to another. Supplementary information from soil survey database will be used for conversion of classification taxa. The definition of Histosols includes following requirements and their correspondence with taxa of Latvia Soil Classification.*

WRB definition	*Correspondence with Latvia soil taxa*
Soils having organic material, either:	
1. starting at the soil surface and having a thickness of ≥ 10 cm and directly overlying continuous rock or technic hard material, or coarse fragments, the interstices of which are filled with organic material;	*Rendzina*
2. starting ≤ 40 cm from the soil surface and having within ≤ 100 cm of the soil surface a combined thickness of either:	
a. ≥ 60 cm, if ≥ 75% (by volume) of the material consists of moss fibres; or	*Typic raised bog peat soil*
b. ≥ 40 cm in other materials.	
– *old alluvium*	*Alluvial muck soil*
– *well decomposed fen peat*	*Fen peat humic soil and Fen peat mucky-humus soil*
– *medium decomposed fen peat with sphagnum and hypnum additions*	*Transitional mire mucky-humus soil and Typic transitional mire soil*

There are very rare Rendzinas in Latvia and they are not used for farming. Typic raised bog peat soils also are not under tillage, but mostly used for peat extraction or few of them for cranberry cultivation. Therefore only other types of soil could be relevant for agricultural activities and mostly are used as permanent grasslands.

Key words: *soil classification; greenhouse gas inventory; organic soils.*

THIRTY YEARS OF REDUCED TILLAGE OR STRAW MANAGEMENT HAD MINOR EFFECTS ON SOIL CARBON SEQUESTRATION

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Abstract. *Reduced tillage and residue incorporation are considered to enhance soil carbon sequestration. We studied the effects of tillage and straw management on soil aggregation and soil carbon sequestration in a 30-year split-plot experiment on a clay soil in southern Finland. The experimental plots were under conventional (mouldboard ploughed) and reduced (stubble cultivator) tillage with straw retained, removed or burnt. Wet sieving was done to study organic carbon and soil composition divided in four fractions: 1) large macroaggregates, 2) small macroaggregates, 3) microaggregates and 4) silt and clay. To further estimate the stability of carbon in the soil, coarse particulate organic matter, microaggregates and silt and clay were isolated from the macroaggregates.*

Total carbon stock in the top soil (equivalent to 200 kg m^{-2}) was slightly lower under reduced tillage (5.0 kg m^{-2}) than under conventional tillage (5.2 kg m^{-2}). Based on these results, mouldboard ploughing enables better utilization of the carbon sequestration potential of the total top soil layer compared to reduced tillage where the crop residues are mixed with a smaller quantity of soil. It seems that the decomposition rate was enhanced in reduced tillage compared to the tilled treatment which could be partly explained by the properties of the cultivator. Reduced tillage changed the soil composition by increasing the percentage of macroaggregates and decreasing the percentage of free microaggregates. The enlarging average diameter of the aggregates indicates increased potential to stabilize carbon in microaggregates within macroaggregates. There was no evidence of differences in the composition of the macroaggregates or carbon content in the macroaggregate-occluded fractions. However, due to the higher total amount of macroaggregates in the soil, more carbon was bound to the macroaggregate-occluded microaggregates in reduced tillage. These microaggregates are relatively well protected from decomposers. Compared with ploughed soil, the density of deep burrowing earthworms (Lumbricus terrestris) was considerably higher under reduced tillage and positively associated with the percentage of large macroaggregates. The higher density of L. terrestris in reduced tillage may have affected the decomposition rates of crop residues as well as the soil aggregation. The total amount of microbial biomass carbon did not differ between the treatments. Straw management did not have discernible effects either on soil aggregation or soil carbon stock. It is possible that the straw biomass has a smaller significance as C input compared to roots due to the more favourable placement of roots and C input throughout the growing season from root system. Straw incorporation can also induce priming effect in the top soil leading to increased decomposition in the treatments with no straw removal or burning.

Although reduced tillage can improve clay soil structure, generally the chances to increase topsoil carbon sequestration by reduced tillage or straw management practices seem to be limited in cereal monoculture systems of the boreal region. This may be related to the conditions of the boreal environment: generally high carbon content of soils, precipitation level favouring decomposition and aggregate turnover in the winter.

Key words: *reduced tillage, stubble management, soil carbon, soil aggregation, earthworm.*

EFFECT OF LIMING ON THE DYNAMICS OF WATER-STABLE AGGREGATES AND ORGANIC CARBON IN MORAINE LOAM SOIL

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Abstract. *The paper summarises the data of field and laboratory trials made in Lithuania (Vezaiciai Branch of Lithuanian Research Centre for Agriculture and Forestry) during the period of 1996-2013. The effect of liming with different intensity (at a rate 0.5 every 7 years and 2.0 every 3-4 years) was investigated in the topsoil of acid moraine loam Bathygleyic Dystric Glossic Retisol on the dynamics of water-stable aggregates and organic carbon. Data showed that systematic liming over 56 years (1949-2005) affected the structure of moraine loam soil. The largest amount (68.4-72.1%) of water stable aggregates (>0.25mm) was determined in the relatively most intensively limed soil when perennial grasses and winter wheat were grown in 2002-2003. During the study period the decrease of water-stable aggregates was appointed in both soil backgrounds: acid (from 57% to 25%) and limed (from 72% to 29%) soil. These data suggest that the climatic conditions (swelling clay under warm and wet conditions in autumn-winter periods and drying and rewetting cycles in spring-summer periods) have a substantial negative effect on the aggregates formation. The effect of systematic soil liming on the distribution of soil organic carbon and it's fractional composition was evaluated. Study showed that periodical liming decreased the amount of organic carbon in the soil. Soil organic carbon amount was approximately by 0.11-0.18 persentage points lower compared to the unlimed plots (1.44%). Periodical liming significantly decrease the content of humic and fulvic acids and dissolved organic carbon content, as one of labile fractions of soil organic carbon. Fulvic acids was dominated in the soil in all treatments, that could be associated with a slow humification processes in the soil.*

Key words: *soil, aggregates, organic carbon, liming.*

INTRODUCTION

Soil aggregates stability is a crucial soil property affecting soil sustainability [1]. Physical protection of soil organic matter by aggregates is considered to be an important mechanism for soil carbon stabilization [2]. Soil organic carbon (SOC) has been increasingly considered as an indicator of soil quality, one of the component of biosphere sustainability and stability [3]. The SOC does not degrade completely to carbon dioxide. It forms humic substances through secondary synthesis reactions. Humic substances account from 65% to 75% of the SOC and are also important aspects of soil fertility as they are involved in the stabilization of soil aggregates and binding of anthropogenic organic chemicals [4],[5]. Dissolved organic carbon (DOC) represents one of the most mobile and reactive organic matter fraction in the ecosystem, which is much more sensitive to soil management than is SOC as a whole, and can be used as a key indicator of soil natural functions [6],[7]. According to Haynes (2000), SOC (total and labile) content are important in relation to water-stable aggregation [8]. In accordance with Bronich (2005), aggregation results from the rearrangement, flocculation and cementation of soil particles. It is mediated by soil organic carbon, biota, ionic bridging, clay and carbonates. The complex interactions of these aggregates can be synergetic or disruptive to aggregation. Clay-sized particles are commonly associated with aggregation by rearrangement and flocculation, although swelling clay, drying and rewetting cycles can disrupt aggregates. Rewetting events after a drought produce a pulse of soil respiration that leads a loss of carbon from soil and destruction (crushed 9-4mm aggregates) of internal structure of soil, especially in Mediterranean ecosystems. Therefore maintaining high stability of soil aggregates and large amount of organic carbon is necessary for sustaining soil productivity and decreasing soil degradation [9].

Dynamics of organic carbon and soil aggregates can be significantly influenced by management practices and environmental changes [9]-[12]. Application of organic substances and lime materials could be an effective measure for improving the soil physical and chemical properties and the fertility of the moraine loam soil (*Bathygleyic Dystric Glossic Retisol*) [13],[14]. Liming effect on the content of SOC and stabile aggregates in soil is diverse and not always positive. According to Chan and Heenan (1999), SOC loss as a result of liming was mainly (up to 84% of total loss) in the form of light fractions bound to macro aggregates [15]. Increased aggregate stability in limed soil suggested about the formation of new bonding involved Ca bridges. According to a Swedish study, an intensive liming is appropriate until the base saturation of soil does not reach 70% [16]. When soil pH is less than 5.5, microbial activities of nitrifying bacteria are lower and SOC mineralization rate is reduced [17]. In summary, the soil texture, the type of lime materials and their exposition time as well as climatic conditions are very important factors for the liming efficiency on soil structure and stocks of carbon. There exist opinions that liming efficiency depends on geochemical environment that lime materials get into.

The aim of this particular investigation is to evaluate the changes of acid moraine loam soil water-stable aggregates and organic carbon content under long-term liming conditions.

MATERIALS AND METHODS

Study site. The field experiment was conducted during the period of 1996-2013 at the Vezaiciai Branch of Lithuanian Research Centre for Agriculture and Forestry, on the eastern part of the seacoast lowland with moderately warm, humid agro-climate. Seeking to determine the dynamics of water-stable aggregate and soil organic carbon, the analysis were done in 1996 (after 50 years of systematic soil liming) and in 2013 (after 64 years of liming). This long-term field experiment was started in 1949. Object of investigation – naturally acid soil and the same soil exposed to different liming intensity (Table 1). The soil of the experimental site is *Bathygleyic Dystric Glossic Retisol* (texture – moraine loam with clay-sized particles content of 12-14%). Before the start of the experiment (1949) the arable soil layer thickness was19-22 cm, soil carbonates were found deeper than 2 meters below the surface. Arable soil layer was very acid (pH_{KCl} 4.2-4.4), high levels of plant-available aluminium in the arable layer of soil (70-100 mg kg^{-1}), amount of bases in topsoil was low 25-50%, content of humus was 2.0-2.9%, low levels of phosphorus (plant-available P_2O_5 50 mg kg^{-1}) and potassium (plant-available K_2O 130 mg kg^{-1}).

Table 1

Experimental design, Vezaiciai, 1949-2013

Liming intensity	Amount of $CaCO_3$ applied, t ha^{-1}		Total amount of $CaCO_3$ applied, t ha^{-1}
	1949-1998	1998-2005	1949-2005
Unlimed	–	–	–
Periodical liming using ×**0.5** of the liming rate calculated based on the soil hydrolytic acidity (3.3 t ha^{-1} $CaCO_3$) **every 7 years**	18.1	–	18.1
Periodical liming using ×**2.0** of the liming rate calculated based on the soil hydrolytic acidity (15.0 t ha^{-1} $CaCO_3$) **every 3-4 years**	89.9	15.0	104.9

Applying the long-term liming system (primary (1949), repeated (1965) and periodical liming (1985-2005)) during the period of 1949-2005, formed the different soil pH levels (Table 2).

Table 2

Effect of liming of topsoil chemical properties

Treatments	pH_{KCl}		Al^{3+}, mg kg^{-1}		Total N, %		P_2O_5, mg kg^{-1}		K_2O, mg kg^{-1}	
	1996	*2013*	*1996*	*2013*	*1996*	*2013*	*1996*	*2013*	*1996*	*2013*
Unlimed	4.0	4.1	98.05	99.86	0.100	0.110	197	160	265	108
0.5 rate every 7 years	5.9*	5.4*	27.12*	23.75*	0.110	0.112	166	139*	159*	90*
2.0 rate every 3-4 years	6.8*	6.4*	0.03*	0.18*	0.110	0.111	192	118*	167*	82*

*Note: * - significantly different from control (P < 0.005)*

Periodical liming was done by pulverized limestone (92.5% $CaCO_3$) on the background of primary and repeated liming by slaked lime. Minimal organic fertilizing (40 t ha^{-1} manure during 7-field rotation), conventional tillage and intensive crop rotation: sugar beets, spring barley with under-sowing grasses, perennial grass (two years), winter wheat, vetch-oats mix for grain and pees-barley mix for forage. In 2008, the long-term experiment was restructured. In 2005-2013 soil hasn't been limed repeatedly. Crop rotation was shortened to 4-field: spring barley with under-sowing grasses, perennial grass (two years), winter wheat and spring rape. Before the soil limed with relatively lower intensity (by 0.5 rates every 7 year) during study period was low acid (pH_{KCl} 5.4-5.9) and soil limed with relatively higher intensity (2.0 rates every 3-4 year) reached the close to neutral reaction (pH_{KCl} 6.4-6.8). In these essentially different by pH soils the study of structure and organic carbon compounds was made.

Soil analysis. Soil structure. The soil samples for soil structure analyses were taken from the topsoil (0-20cm) when the harvest of various crop rotation plants was taken off in periods: 1996-1999, 2002-2005 and 2008-2011. Soil aggregate stability in water was estimated according to Savinov in Vezaiciai Branch of Lithuanian Research Centre for Agriculture and Forestry [18].

For the organic carbon analysis, soil samples were taken randomly by using a steel auger from three replicates of the topsoil (0-20 cm) after the harvest in 2013. All samples were air-dried, visible roots and plant residues were manually removed. Then the samples were crushed, sieved through a 2-mm sieve and homogeneously mixed. For the analyses of SOC content the soil samples were passed through a 0.25-mm sieve. Analyses of SOC and DOC were carried out at the Chemical Research Laboratory of Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry. SOC content was determined by photometric procedure at the wavelength of 590 nm using the UV-VIS spectrophotometer Cary 50 (Varian) equipped with computer program, and glucose as a standard after wet combustion according to Nikitin (1999) [19]. Soil organic carbon fractional composition was determined by Ponomariova and Plotnikova version of classical Tyurin method [20]. Dissolved organic carbon (DOC) was analyzed using an ion chromatograph SKALAR in water extract at soil–water ratio 1:5.

Statistical analysis. Statistical analysis was done using the computer program ANOVA from the package SELEKCIJA. One-way analysis of variance was then used to analyse the differences in the tested parameters among the treatments. The least significant difference method (LSD) at the 5% probability level was used to test the significance of differences between treatment means [21].

RESULTS AND DISCUSSION

Structure of acid moraine loam soil due to low amount of water-stable aggregates is poor and changeable under various climatic and anthropogenic factors. Results of our investigations showed that 56- year of systematic liming (by 0.5 rates every 7 year and 2.0 rates every 3-4 year) on the background of minimal organic fertilizing and conventional tillage, affected the structure of moraine loam soil (Table 3). According to 11- years data the largest amount (68.4-72.1%) of water stable aggregates (>0.25mm) occurred in relatively most intensively limed soil when perennial grasses and winter wheat were grown in 2002-2003.

The increase (by 28-34%) of water stable aggregates was determined in limed soil compared to the unlimed. These data suggest that growing of perennial grasses in limed soil is an effective measure for the improvement of moraine loam soil structure. During the study period the decrease of water-stable aggregates was determined in both acid (from 57% to 25%) and limed (from 72% to 29%) soil. These data suggest that the climatic conditions (swelling clay under warm and wet conditions in autumn-winter periods and drying and rewetting cycles in spring-summer periods) has a substantial negative effect on aggregates formation. Similar results were obtained in long-term field experiments by other researches [22]. Also, the decrease of water stable aggregates in moraine loam soil is caused by the intensive anthropogenic activity inducing the decrease of organic carbon.

Soil organic carbon. Soil organic carbon is the most important indicator of soil quality and productivity. The data about the liming effect on the dynamics of SOC in soils are often contradictory, especially in arable soils. According to Abril (2008), intensive soil liming resulted higher SOC content compared to the unlimed soil [23]. However, other studies, showed that liming decreases the SOC content due to increased microbial activity [24],[25].

Our study showed a negative statistically significant effect of liming on SOC amount in the soil (Table 4). In 2013, SOC amount was 1.44% for the unlimed treatment and in periodical liming was thus approximately by

0.11-0.18 persentage points lower compared to the unlimed plots. The same tendency was observed in 1996. The lowest amount of soil organic carbon in 1996 and 2013 (1.28 and 1.44 respectively) was obtained in the periodically limed soil using 2.0 liming rate. It could be related to soil pH, which influences the mineralization processes in the soil. The higher soil pH (more than 6.5 pH_{KCl}) activates carbon mineralization processes in soil, and intensive soil liming, when pH_{KCl} ranges from 6.8 to 7.2, can reduce soil organic carbon amount in soil. The humus content showed similar patterns as for SOC content.

Table 3

The effect of periodical liming on the content (%) of water-stable aggregates (>0.25mm)

Treat-ment	Investigation year and vegetation type										
	1996 winter wheat	**1997** mixture of vetch and oat	**1998** mixture of pees and barley	**2002** pere-nnial grasses	**2003** winter wheat	**2004** mixture of pees and barley	**2005** mixture of vetch and oat	**2008** spring barley	**2009** perennial grasses	**2010** winter triticale	**2011** spring rape
Unlimed	57.3	50.4	56.5	56.2	50.9	40.1	42.0	34.2	37.7	26.0	24.8
0.5 rate every 7 years	51.5	48.9	53.4	64.7	63.8*	53.5*	51.4*	47.1*	43.8	32.0	29.8
2.0 rate every 3-4 years	56.0	55.9*	58.4	72.1*	68.4*	50.5*	50.6	42.4	53.2*	30.5	28.8

*Note: * - significantly different from control (P < 0.005)*

Table 4

The effect of periodical liming on the content of soil organic carbon and humic substances

Treatments	Humus,%		Soil organic carbon,%		HA/FA	
	1996	**2013**	**1996**	**2013**	**1996**	**2013**
Unlimed	2.21	2.48	1.28	1.44	0.53	0.79
0.5 rate every 7 years	2.33*	2.29*	1.35*	1.33*	0.60*	0.93*
2.0 rate every 3-4 years	2.20	2.17*	1.27	1.26*	0.59	0.83

*Note: * - significantly different from control (P < 0.005)*

One of the most resumptive indicators of humus quality is the HA/FA ratio. This ratio increased in the periodical limed soil (0.83-0.93) at the both liming rates. The lowest HA/FA ratio was determined in the unlimed soil. In 1996, this ratio was significantly lower in all treatments compared to 2013. The increase of HA/FA ratio showed that the SOC in general became richer in humic acids compared to unlimed soil. It means that the quality of humus improved.

Table 5

The effect of periodical liming on quantity of soil organic carbon forms, Vezaiciai, 2013

Treatments	Dissolved organic carbon	Humic acids	Fulvic acids
	$g\ kg^{-1}$		
Unlimed	0.189	0.493	0.617
0.5 rate every 7 years	0.161*	0.506*	0.542*
2.0 rate every 3-4 years	0.156*	0.498	0.595*

*Note: * - significantly different from control (P < 0.005)*

There was found a statistically significant effect of liming on quantity of carbon forms accumulated in the soil (Table 5). The labile fractions of SOC play an important role in the formation of aggregates, and because

of their rapid turnover time they are the most sensitive to changes in soil management. The highest DOC content (0.189 g kg^{-1}) was determined in the unlimed soil. Periodical soil liming resulted in lower DOC content compared to unlimed soil. Various mechanisms have been suggested to explain this phenomenon, such as increased organic matter solubility, increased microbial activity, an increase in the production of soluble molecules due to the decrease in biologically toxic Al at higher pH, and the displacement of the previously adsorbed DOC by other mobilised anions [26].
The effect of periodical soil liming on the distribution of soil carbon in chemical humus fractions was evaluated. Periodical liming significantly decrease the content of humic and fulvic acids. Significant higher carbon content of humic acids was established in the periodical limed soil using 0.5 of the liming rate (3.3 t ha^{-1} $CaCO_3$) every 7 years (0.506 g kg^{-1}). Fulvic acids was dominated in the soil in all treatments. This could be associated with a slow humification processes in the soil, due to the low carbon content, when the content of fulvic acids is always considerably higher compared with humic acids in the soil [24].

CONCLUSIONS

Systematic periodical liming over 56 years (by 0.5 rates every 7 year and 2.0 rates every 3-4 year) on the background of minimal organic fertilizing and conventional tillage, has a positive effect on structure of moraine loam soil *(Bathygleyic Dystric Glossic Retisol).* The largest amount (68.4-72.1%) of water stable aggregates (>0.25mm) occurred in relatively most intensively limed soil than perennial grasses and winter wheat were grown in 2002-2003.

The decrease of water-stable aggregates was appointed in both acid (from 57% to 25%) and limed (from 72% to 29%) soil during the study period. It was influenced by climatic conditions.

Systematic periodical liming decreased the soil organic carbon amount in the soil. SOC amount was approximately by 0.11- 0.18 persentage points lower compared to the unlimed plots (1.44%).

The unlimed soil contained more labile, dissolved organic carbon, which shows it's higher predisposition to transformation. Periodical soil liming resulted in lower dissolved organic carbon content due to the decrease in biologically toxic Al at higher pH.

Periodical liming significantly decrease the content of humic and fulvic acids. Fulvic acids were dominated in the soil in all treatments as a consequence of the low carbon content and slow humification processes in the soil.

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CARBON ACCUMULATION AND HUMIFICATION IN SOILS OF ABANDONED FORMER AGRICULTURAL LANDS IN THE HEMIBOREAL ZONE

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Abstract. *Abandonment of the agricultural land is a common, topical problem in many post-soviet countries, including Latvia. These changes impact nutrient cycling, soil properties. The results of the study of abandoned agricultural lands in the hemiboreal zone in Latvia validated the theory that after afforestation, in long term, soil accumulates organic carbon (C_{org}). During the first 30 years of abandonment, C_{org} content in mineral topsoil does not present a significant increase; it varies from 42 to 43 t ha^{-1}. More rapid C_{org} content increase was observed in the territories where the age of the forest land had exceeded 30 years; the mean C_{org} content in 31-60 years old forest stands reached 51.3 t ha^{-1}. The C_{org} content which has been accumulated in litter increases in older forest sites. In spruce and mixed forest stands, where age of the forest had exceeded 60 years, the mean C_{org} content in litter was 17.8 t ha^{-1}. Afforestation also changes the content of humic substances and the humification rate in the mineral topsoil. In agricultural lands C of humic substances (C_{hs}) constituted 65% of total topsoil C_{org}. In sites where age of the forest land was more than 30 years C_{hs} exceeded 75% of total C_{org} amount.*

Key words: *Afforestation, land use, change, humic substances.*

INTRODUCTION

Abandonment and afforestation of agricultural land (AL) are common in many European countries [3], [20]. Land use change affects soil genesis, soil morphology, soil chemical and physical properties [2],[16].

Afforestation of agricultural land in the long-term leads to increased organic mattter (OM) and C content [17],[24]. However, organic carbon (C_{org}) content in soil does not change or even may decrease during the first years of afforestation. More intense C accumulation starts in a later period, which may differ for forest types, but, usually occurs when annual C inflow from litter is larger than C loss due to degradation [17],[24].

Furthermore, afforestation of AL affects the structure and chemical properties of soil OM and humification processes [6]. Land use change also leads to changes in soil moisture and temperature regime, that affects intensity of OM degradation [17]. The main changes occur in topsoil within the A horizon. Inherited OM properties from agricultural land use decline with the age of the forest stands [6].

C sequestration and OM humification processes in soil after AL afforestration are affected by climate [14]. There is minimal information on these processes in the hemiboreal zone, where the climate is more humid than in the nemoral zone (e.g. summers are shorter, and winters are longer and colder). The main tree species are the conifers spruce (*Picea abies*) and pine (*Pinus silvestris*), and the deciduous species birch (*Betula sp*) and aspen (*Populus tremula*). The broad-leaved tree species oak (*Quercus robur*), ash (*Fraxinus excelsior*) and lime (*Tilia cordata*) occur in lower amounts. In Latvia, large-scale abandonment of the agricultural lands and overgrowing by trees starts in the first half of the 20th century, but more intensive afforestation occured after 1990 with the collapse of the Soviet Union [18],[20]. In the beginning of the 20th century, forests covered only 25.2% of Latvia's total land area [18], but in 2007 forests covered 56% of state's total area. During the last decade, agricultural land area decreased by 1.4%, while forest area increased by 0.8%. Thus Latvia provides a good model territory where the impact of the afforestation of the former agricultural land on the landscape, biodiversity and soil can be determined.

The aim of the study was to estimate changes of soil C_{org} content and OM properties in topsoil (O and A horizons), in territories with different age of the forest land in moraine upland in hemiboreal zone.

MATERIALS AND METHODS

Field studies and soil analysis

Field work was carried out from 2009 till 2013. Sampling plots were established on abandoned agricultural land, afforested former agricultural land and forest land with different age. A total of 58 sampling plots were described. In forested sites, tree species were recorded and tree age was estimated using a Pressler's auger. The age of the oldest stands was determined from forest inventory material and historical maps.

Soil profiles were described according to the international FAO WRB classification system [10]. Soil samples from litter O and mineral Ap, Ah horizons (from the upper 5 cm and from the middle part of the A horizon) were collected in all sampling plots.

Physical and chemical analyses (soil texture, soil pH_{KCl}, exchangeable cations: calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), total organic carbon (C_{org}), humic substances (C_{hs}), index of humification (HIX)), of soil samples were conducted in the Soil Laboratory of the Faculty of Geography and Earth Sciences, University of Latvia.

Soil texture by size fractions were determined by pipette analysis [25] and according to USDA soil textural classes. Soil pH was measured with a glass electrode in 1M KCl (1:2.5 mass to volume ratio). Total organic carbon (C_{org}, %) was determined using a total carbon analyzer „Shimadzu TOC-Vcsn".

Humic substances were purified according to International Humic Substance Society (IHSS) standard methods [23]. Organic carbon content in humic substances (C_{hs}, %) was determined with a „Shimadzu TOC-Vcsn" total carbon analyzer.

Alkaline extracts of humic substances were analyzed for humification index. Fluorescence spectra were used to determine the organic matter humification index (HIX) according to methodology [11].

Data analysis

For data analysis purposes, all sampling plots were divided into groups by age of the forest land: 1) unmanaged AL, without tree vegetation; 2) afforested AL, age of trees less than 15 years; 3) afforested AL, age of trees from 16 to 30 years, O horizon has begun to form; 4) new forest land, age of forest land from 31 to 60 years; 5) forest land, where age of the forest land is from 61 to 100 years; 6) relatively old forest land, age of the forest land exeeds 100 years.

One-way analysis of variance (ANOVA) was performed to compare properties (C_{org}, C_{hs}, $C_{hs}/C_{org,}$ HIX, pH_{KCl}, BD) of the mineral soil between the AL, afforested AL and forest land. Tukey and Scheffe HSD post-hoc tests (α=0.05) were made to determine the significance of differences betveen groups. Calculations were performed using SPSS PASW Statistics 18 software.

Principal component analysis (PCA) using PC-ORD 5.0 software was carried out to determine relationships between afforestation age (years) and the topsoil properties.

RESULTS AND DISCUSSION

Organic matter and C content

The mean C_{org} concentration in the studied AL topsoil was 1.3 (±0.4)%. In areas overgrowing by trees, dense grass vegetation with *D. glomerata*, *F. pratensis*, *Taraxacum officinalisun* and *Ahillea millefolium* dominated, and O horizon was absent. Litter patches of 1-year-old leaves had started to accumulate on the soil surface when age of trees exceeded 10 years. Mean C_{org} concentration in mineral topsoil of young tree stands was 1.49%. Higher C_{org} concentration (>2%) occurred in silty clay loam soils under and overstorey of aspen and gray alder (table 1).

In 16- to 30-year-old tree stands, where the AL was under *Betula pendula, Alnus incana* and *Picea abies*, max thickness of the O horizon reached 2.0 cm, litter mass was 23.1 (±1.34) $t\ ha^{-1}$. In the 20-year-old *Betula pendula* and 25-year-old *Alnus incana* stands a continuous O horizon had not formed. The lowest C_{org} concentration (mean 1.59%) was in sites overgrowing by *Picea abies*, and the highest concentration in *Alnus incana* stands, where it reached a mean of 2.5%.

The thickness of the O horizon in sites where the age of the forest land exceeded 30 years was dependent on the tree species. Thinner litter layers occurred in *Alnus incana* stands. Thickness of the litter layer varied from 0.3 to 0.5 cm, and mass from 2.5 to 7.8 $t\ ha^{-1}$ in 35- to 40-year-old *Alnus incana* stands. The thickest litter O horizons, as well as the highest litter amount were found in *Picea abies* stands, where the O horizon depth was up to 10 cm and mass of the litter was 134 $t\ ha^{-1}$.

Table1

Changes of the soil morphological properties. Mean thickness of O and A horizons, litter weight and bulk density in the studied soils.

Standard deviations (error bars) of the means are shown in parentheses.

Forest land age	Sampling plots	O horizon depth, cm	Litter mass, *t ha^{-1}*	A horizon depth, cm	Soil density g cm^{-3}, 0-5 cm
AL	5	-	-	30.6 (±6.8)	1.21 (±0.12)
1-15	25	0.01 (±0.06)	0.1 (±0.6)	28.9 (±4.9)	1.12 (±0.24)
16-30	6	0.51 (±0.77)	7.9 (±9.1)	25.3 (±5.7)	1.01 (±0.09)
31-60	10	2.38 (±3.22)	20.0 (±32.1)	22.8 (±6.5)	1.06 (±0.06)
61-100	8	4.25 (±2.72)	60.5 (±48.8)	15.9 (±4.2)	1.05 (±0.15)
>100	4	3.1 (±2.10)	60.8 (±46.6)	15.0 (±10.1)	0.93 (±0.15)

The A horizon was thinner in the oldest forest sites. Among forest sites of age >60 years, a lower C_{org} concentration (1.5%) occurred in the mineral topsoil in the Ergli sampling site in Arenosols and Cambisols soils, where signs of podzolization were detected. Comparing mean C_{org} concentrations within forest land age groups (table 2), a gradual increase of C_{org} concentration was detected. During the first years of afforestation there was no significant change in C_{org} concentration in soil. Increase in C_{org} concentration was observed in 16- to 30-year-old forest sites. However, due to high variability, these differences were not statistically significant ($p<0.05$).

OM properties were less variable and age of forest land had greater effect on observed properties. The concentration of humic substances in soil OM (C_{hs}/C_{org}) in AL soils was 65%, compared to 73% in young afforested soils. A lower C_{hs}/C_{org} ratio (mean 59%) occurred in Stagnosols and Gleysols soils. In the oldest forest sites, C_{hs}/C_{org} ranged from 65 to 89%, and there was no significant relationship between index and dominant tree species, soil group, and soil texture. Mean C_{hs}/C_{org} was higher in the older groups (table 2), and was significantly ($p<0.05$) higher in forest soils in forest land with age more than 30 years, compared to AL soils.

Afforestation caused changes in the mineral soil OM humification rate. There was no direct correlation between age of the forest land and OM humification index (HIX) ($r^2=0.3043$), but the OM humification rate in topsoil slightly increased with age of the forest land. In the abandoned AL and in the overgrown AL mean HIX values (0.64 and 0.62) did not exceed the lowest HIX values of the old forest soils. Also, mean HIX values in the AL and in the 1-15 years old afforested soils were significantly lower than in the sites where age of the forest land exceeded 60 years (table 2).

Forest evolution on AL was significantly related with soil reaction. Mean pH_{KCl} values changed from 5.5-5.6 in AL and 1- to 15-year-old site soils to 4.4 and lower in the oldest forest soils.

Table 2

Characterization of soil properties (mean values).

Different letters (a, b, c...) shows statistically significant differences ($p<0.05$) [according to comparison (Tukey and Scheffe test)].

Age group (age of forest land, years)	0	1-15	16-30	31-60	61-100	>100
C_{org} %	1.3^{a}	1.5^{a}	1.9^{a}	2.7^{a}	2.6^{a}	2.9^{a}
C_{hs} %	1.2^{a}	**1.0^{ab}**	1.3^{a}	**2.3^{ac}**	1.9^{a}	1.7^{a}
C_{hs}/C_{org}, %	**65^{a}**	**71^{ac}**	77^{abc}	**85^{bc}**	78^{abc}	**80^{c}**
HIX	**0.64^{a}**	**0.62^{a}**	0.61^{ab}	0.69^{ab}	**0.71^{b}**	**0.73^{b}**
pH_{KCl}	**5.5^{a}**	**5.6^{a}**	4.2^{ab}	4.3^{ab}	**3.7^{b}**	**3.9^{b}**
BD, g cm^{-3}	**1.19^{a}**	1.25^{ab}	1.17^{ab}	**1.06^{b}**	**1.05^{b}**	**1.05^{b}**

Soil carbon content

C_{org} content in mineral topsoil was mainly related to C_{org} concentration and thickness of the topsoil horizons. In abandoned AL, C_{org} content in the soil A horizon varied from 32.8 to 59.4 *t ha^{-1}*. In sites where age of the forest land did not exceed 15 years, C_{org} content in A horizon varied from 16.9 *t ha^{-1}* to 48.5 *t ha^{-1}*. In 16- to 30- year-old forest sites, the lowest C_{org} content (36.6 *t ha^{-1}*) occurred in *Picea abies* stands, and in *Alnus incana* stands C_{org} content reached 45.0 *t ha^{-1}*. The Ergli sampling site, where age of the forest land exceeded 30 years, had soils with the lowest C_{org} content in mineral topsoil. In 60- and 140-year-old *Picea abies* stands, C_{org} content was only 13.1 and 11.2 *t ha^{-1}*. In 60-year-old *Betula pendula* stands, C_{org} content was 21.2 *t ha^{-1}*. In soil of other old forest sites, A horizon carbon content varied from 22.1 to 57.6 *t ha^{-1}*, and in the 70 years old *Picea abies* stand it reached 60.2 *t ha^{-1}*.

During the first years of afforestation, C_{org} content in A horizon increases (figure 1). During the development of forest, in soil, distribution of C_{org} in the A horizon also changed. In abandoned AL and in the young stands, C_{org} was distributed evenly through the profile: the top 5 cm accumulated 19% of total C_{org} in A horizon. In older sites, a greated relative amount of C_{org} occurred in the top 5 cm of mineral soil. In 16- to 30-year-old sites, the proportion of C_{org} in the top 5 cm was 24.2%, in 31- to 60-year-old sites – 30%, and in the oldest sites C_{org} content exceeded 40% of total C_{org} content in the humus A horizon.

Mean C_{org} content significantly ($p<0.05$) differed between AL and 31- to 60-year-old forest soils (figure 1). C_{org} content did not change during the first 30 years of afforestation, but lower C_{org} content in mineral topsoil was observed in 60- to 100-year-old forest land soils.

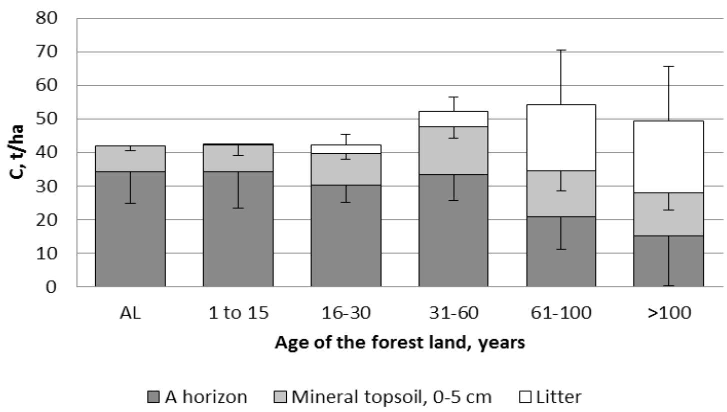

Figure 1. **Mean C content t ha^{-1} in AL and in forest land of different age**

During forest development significant C_{org} content accumulated in the forest floor. In 30- to 61-year-old forest sites, the forest floor accumulated 1.81 *t ha^{-1}* C_{org} on average. Carbon amounts were 6.1 *t ha^{-1}* in gray alder and aspen litter and 11.7 *t ha^{-1}* in spruce litter. In deciduous tree stands with age of the forest land exceeding 60 years, 4 *t ha^{-1}* C_{org} had accumulated in the litter O horizon. In the oldest spruce stands, mean C_{org} content in the litter layer was 17.8 *t ha^{-1}*.

The natural succession of topsoil properties, alongside those of vegetation, is well shown by principal component analysis (results not shown). The obtained results show that soil properties changed with age of the forest land: decrease in thickness of the A horizon, accumulation of litter horizons, which together lead to C_{org} accumulation in topsoil. These processes decreased soil reaction, as well as increased humification rate of the soil organic matter. These processes depends on soil texture (proportion of sand, clay and silt). The PCA also showed that, alongside age of the forest land, spruce (*Picea abies*) litter promoted formation of the O horizon and the accumulation of C_{org} in this horizon.

Discussion

In Latvia moraine hills have high spatial variation of soil texture and soil moisture conditions, which affect C accumulation in soil. Accumulation of OM and C in soil was evident at the beginning of secondary ecological succession, but spatial variation of these indicators was greater and did not allow to detect significant differences in the first years of secondary ecological succession. OM content in topsoil is influenced by many factors, firstly by soil properties and soil geographical conditions (exposition, moisture conditions), and secondly by history of land management. Land management and cultivated crops [7], as well as intensity and properties of fertilisation [1] influence organic matter content in soil. C concentration in arable land is lower than in pastures [8]. Ambiguous C concentration changes during the first years of afforestation may be related to differences of OM content in soil in pastures and arable lands. Some studies have found a decrease of C content during the first 5 years after afforestation [17], or even up to 15 years after natural succession. In other studies [21] a decrease of C was not observed, or there was an increase [25]. The results of our study confirms previous results [16] from the hemiboreal zone which show that AL abandonment and gradual overgrowing do not cause any significant changes in topsoil properties and organic matter content, as well as C accumulation in sandy loam and silty loam soils.

C concentration and content in soil increased during further stages of forest development. More rapid C increase in soil usually correlates with increase of OM production and decrease of degradation intensity. In temperate latitudes, an equilibrium usually occurs after 20 to 25 years of afforestation [5],[16], but in some cases up to 40-60 years may be required to reach equilibrium [13]. High variation of C content in soils, and the fact that most of the studied forest sites in the 31- to 60-year age group was 35 to 40 years, suggests that this kind of production/degradation equilibrium in the hemiboreal zone is reached during the first 40 years after afforestation.

During forest development, the effects of composition of forest tree stands and soil parent material become greater. Study shows that ecological succession on sandy loam, silt loam soils is associated with an increased proportion of spruce in developing forest tree stands. Hansson [9] concluded that, in stands with similar age but different tree species, litter production and C content in mineral soil may differ significantly.

The observed decrease of carbon in mineral topsoil may be related to the podzolization process [17]. A decrease of pH and increasing amount of coniferous litter accelerates podzolization, which promotes leaching of soluble organo-mineral complexes and C to deeper soil layers [15]. Morphological properties of podzolization in nutrient rich glacial till soils in spruce stands in the hemiboreal zone is evident during the first 100 years of afforestation of AL [16].

Differences of thickness of the soil A horizon must be considered in context of the history of land management. A thinner humus horizon in former agricultural lands afforested 60 years ago may be explained not only by podzolozation, but also the practice of scarification of arable land soils only up to a 15 cm depth before 1940, which resulted in undisturbed soil E and B horizons in soils formed on glacial till deposits.

The results of our study, similar to those of Cerli studies [6], show that progress of afforestation process affects not only C content in soil, but also composition and humification rate of soil organic matter. A low soil organic matter humification rate in abandoned AL and in young tree stands is related to high organic matter mineralization in AL soils [4]. The gradual increase of organic matter humification rate in older forest sites can be explained by increased leaching of soluble organic matter from the litter layer, which increases in the later stages of litter decomposition, but not in fresh litter [12].

pH changes and consequent changes in communities of soil meso and micro fauna [19] can explain the increase of proportion of humic substances (C_{hs}/C_{org}, %) in soil. Proportion of humic substances in mineral soil increases by transport of highly oxidized organic matter from soil organic layers [6]. The higher proportion of humic substances in coniferous tree forest soils can be explained by poorer soil fauna, as lack of penetrating fauna does result in mechanic mixing and input of poorly decomposed, non humified organic matter.

CONCLUSIONS

1. Organic carbon concentration varied in mineral topsoil, and was characterized by high variability.
2. During the first years of abandonment and afforestation of AL, there were no significant changes in C_{org} content in soil.
3. A more rapid and significant increase in C_{org} content in mineral topsoil occurred in 30- to 60-year-old forest stands, which was followed by a smaller decrease.
4. In the oldest forest lands dominated by spruce, more C_{org} had accumulated in the litter O horizon.
5. Afforestation of AL caused changes in the proportion of humic substances and humification rate in soil, and humification rate of soil organic matter increased with age of the forest land.

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IMPACT OF NITROGEN FERTILIZATION ON NUTRIENT UPTAKE AND STOICHIOMETRY IN WINTER WHEAT

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Abstract. *A crop well balanced with plant nutrients is essential for obtaining optimal yield and high quality food products. Crop production is often carried out with large and well regulated input of nitrogen (N) and other macronutrients whereas the input of micronutrients often is low. This has raised concern about the potential risk of increasing micronutrient deficiencies in high yielding crops as well as causing lower content of essential trace elements in food products. However, in what way a high N input really influences the uptake of other plant nutrients is not fully examined. In addition, the seasonal dynamics in plant nutrient uptake have been thoroughly investigated for N whereas the seasonal patterns for other nutrients need further attention to better understand the crop requirements throughout the life cycle of field crops. The aims of this study were (1) to examine how the rate of N fertilization affects plant nutrient uptake and stoichiometry in shoot and grain of wheat; and (2) to study the temporal dynamics of different nutrients throughout the growing season and how the seasonal pattern is influenced by N input. Eight field experiments at eight different locations in south and central Sweden were used in the study, and four N treatments were included: Unfertilized control (N0), 80 kg N ha*$^{-1}$ *(N80), 160 kg N ha*$^{-1}$ *(N160) and 240 kg N ha*$^{-1}$ *(N240). Two varieties of winter wheat (cv Julius and Ellvis) were grown and crop samplings were made at tillering (ZS 23-24), stem elongation (ZS 37), flowering (ZS 65) and maturity (ZS 93). At maturity samples were divided into grain and straw. Whole shoot, straw and grain samples were dried, milled and analyzed for N (LECO), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu), manganese (Mn) and boron (B) (ICP-OES).*

Preliminary results showed a biomass increase up to moderate fertilization rates (N160) at all sampled development stages including grain yield. Generally, high fertilization (N240) did not result in further yield increase. However, N concentration in whole shoots and grains increased up to N240 at the three last sampling occasions whereas low N input (N80) did not result in an increased N concentration compared to unfertilized treatments. The concentrations of K, S, Ca, Mg, Zn, Cu and B were positively correlated ($p<0.05$*) with N concentration in the growing plant, whereas P, Fe and Mn showed no correlation with N. A different pattern was found for nutrients in the grain where S, Ca and Cu showed a positive correlation with N, whereas K, P and Mg instead were negatively correlated and Zn, Mn and B showed no correlation. These results indicate that concentrations of several macro- and micronutrients increase at high N fertilization levels, which also indicates that plant requirements of several nutrients increase with high N input and yields. Different temporal dynamics of nutrient uptake were found for different elements. For example, at stem elongation, the crop had taken up approximately 80% of the total N, whereas for several micronutrients only 40-50% had been taken up by the crop. This indicates that the crop could possibly benefit from a supply of these nutrients later in the season compared to N.*

The results from this study will increase our understanding of plant stoichiometry and how it is influenced by N management in a crop production context. Thus, the results may have practical implications for farm consultants and farmers, for example with respect to the appropriate nutrient fertilization rates for different plant nutrients at different yield levels, and the appropriate timing of fertilization application of different plant nutrients during the growing season. Also food quality issues are addressed in terms of essential trace elements in grain and how they are influenced by crop management.

Key words: *nitrogen, nutrient uptake, plant nutrients, plant stoichiometry, winter wheat.*

THE EFFECT OF IRRIGATION ON THE BIOCHEMICAL CONTENT OF LEAFY VEGETABLES

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Abstract. *Leafy vegetables contain a lot of vitamins and minerals Consumers more and more are thinking about a healthy and balanced diet. The aim of the research was to evaluate the effect of irrigation on the content of ascorbic acid and antioxidant activity in lettuce cv.'Grand Rapids' and leafy mustard cv 'Scala'. Experiments were arranged in high plastic tunnels in Pūre Horticultural Research Centre during spring and autumn of 2013. As control was used variant with optimal soil moisture, as experimental plot- with moisture deficit. Available for plants moisture in the soil was detected by tensiometers. The content of ascorbic acid was determined by using titration with 2, 6- dichlorophenolindophenol in acidic solution. Antioxidant activity was determined by using the DPPH assay. The higher ascorbic acid content and antioxidant activity was detected in the control variant with optimal soil moisture .Higher conent ofvitamin C was observed in leaf mustard – three to seven times more than in lettuce. Antioxidant activity did no show quite clear differences regarding vegetable species and growing periods.*

***Key words**: leaf mustard, lettuce,vitamin C, antioxidant activity.*

INTRODUCTION

Leafy vegetables are good source of healthy nutrients in human diet. There is high percentage of carotene, ascorbic acid, riboflavin, folic acid, minerals and vitamins [1]. As human body is unable to synthesis ascorbic acid (vitamin C), it should be provided by diet. Vitamin C is a universal component of all green plants. Minimal suggested daily intake for adults a 60 mg vitamin C. Cabbages and leafy vegetables are the richest source of vitamin C among vegetables vitamin C [3]. Ascorbic acid and carotenoids are involved in ensuring of plants antioxidant properties [4]. Antioxidants protect plants from negative influence of free radicals. Also many human diseases are caused by free radical damages in the body. Vegetables usually contain natural antioxidants which can neutralize free radicals in the human body [5].

Leaf mustard (*Brassica juncea* var. *crispifolia* L.) is widely used for its special flavour and nutritional value. Major flavour components are mainly derived from gluosinoanalate hydrolysis [6]. Those are good source of ascorbic acid, β-carotene, chlorophylls, flavonoids and dietary fiber. 140 g leaf mustard provide with 60% vitamin A and 100% vitamin C of advisable daily dosage [7]. Mustard greens have high antioxidant activity; they can inhibit oxidative damage diseases, for example heart diseases, cancers [6]. Also lettuce (*Lactuca sativa* L.) is good source of carotene, vitamin C, vitamin E and is characteristic with good antioxidant activity [8]. Therefore it is significant source of dietary antioxidants as well. Antiradical activity of lettuce also derives from some phenolic compounds. Also C and E vitamin promote antioxidant activity in lettuce [9, 10].

Relationship between plants, soil and its water resources is tight and complicate. It is important to understand these relationships and use as much efficiently as possible to obtain not only biochemically rich, but also high yielding fresh commodities. One of the most important factors ensuring high quality yield is soil moisture. Irrigation is a basic requirement to ensure optimal soil moisture during the plants growing period. The highest yield and quality can be obtained in optimal moisture conditions during all vegetation season. It means – to have accurate, balanced and agronomical justified irrigation [10, 11]. It should be stressed that not only moisture and crop management influences yield amount and quality. Biological active compounds in plants are depend also on the climate conditions, seasonal changes, cultivar properties, maturity and post harvest treatments or storage conditions [12]. There were found results on investigations performed in other countries indicating that water stress reduce leafy vegetables yield and quality [10, 11]. Irrigation of vegetables is not often investigated in Latvia.

The aim of the study was evaluate effect of irrigation and sowing date on the content of ascorbic acid and antioxidant activity of leaf mustard and lettuce leaves.

MATERIALS AND METHODS

The investigations were carried out in Pūre Horticultural Research Centre in vegetation season of 2013. Experiments were arranged in high tunnels in two growing periods – spring and autumn. First period trials were sown on 8 May, but second – on 11 September. Two leafy vegetable species: lettuce cv.'Grand Rapids' and leaf mustard cv 'Scala' were grown in 3 replications. Two variants of irrigation were compared – experimental plot with moisture deficiency was compared to control variant – optimal soil moisture provided. Total area of each experimental plot was 1 m^2.

Soil moisture and temperature was fixed by soil tensionmeters and thermometers. After sowing all experiment plots were irrigated according to tensionmeters measurements, to provide optimal soil moisture for uniform seed germination. After germination, irrigation was reduced in control variant to keep moisture deficit in soil, but not achieve critical level for plant. In the first growing period from sowing till end of vegetation period optimal soil moisture was provided with irrigation performed 10 times. In the first decade of June weather was very hot and sunny. Average air temperature was +18.6 ^{o}C (max +28.1 ^{o}C) and therefore irrigation was done so often. In variant with moisture deficit irrigation was performed 8 times during growing period. Vegetables were harvested at 11 June. In the second growing period average air temperature was +10 ^{o}C and sunshine days were less. Irrigation was done 8 times in optimal variant, but 5 times in variant with moisture deficit. Yield was harvested at 28 October.

Biochemical analyses were done in Latvia University of Agriculture, Institute of Soil and Plant Sciences. Ascorbic acid and antiradical activity in lettuce and leaf mustard leaves were analysed. The content of ascorbic acid was determined by using titrimetric method with 2, 6 – dichlorophenolindophenol in acidic solution. Bulk sample of all replications was weighted and grinded by pestle and mortar. Two gram samples were placed in a graduated tube, added 50 mL of 1% HCl and 5% H3PO4 solution (1:1) and mixed. After 30 minutes solution was strained by paper filter. Then 10 mL filtrate titrated with 0, 0005 molar 2,6 – dichlorophenolindophenol until faintly rosy colour. Content of ascorbic acid (mg 100 g^{-1}) was calculated by equation (1):

$$m = \frac{V_{titr} \times 0.044 \times V_{sum} \times 100}{V_{anal.} \times m_{weighed}}, \qquad (1)$$

where:

$V_{titr.}$ – for titrated used 2.6 – dichlorophenolindophenol volume, mL
0,044 – amount of ascorbic acid, which reduce 1 mL 0.0005 M 2,.6 dichlorophenolindophenol solution, mg
V_{sum} – amount of filtrate volume, mL
$V_{anal.}$ – amount of analysed solution volume, mL
$M_{weighed}$ – weighed amount of plant material [13].

Antiradical activity was determined using 1.1 – dyphenyl -2 picrylhydrazyl radical (DPPH*) method. An aliquot of the methanolic lettuce extract and leaf mustard extract was added to a DPHH methanolic solution and spectrophotometrically determined at 515nm wavelength. Antiradical activity (%) was calculated by equation (2):

$$ARA = 100 \times (1 - \frac{A_{ss}}{A_0}ARA = 100 \times (1 - \frac{A_{ss}}{A_0}), \qquad (2)$$

where:

A_{ss} – absorbance of the solution at constant state, min
A_0 – absorbance of DPPH solution before antioxidant addition, min [12].

The results were analyzed using ANOVA at significance level of p = 0.05.

RESULTS AND DISCUSSION

Ascorbic acid content in mustard leaf shows significant differences between irrigation variants ($p = 0.02\times10^{-2}$) and growing periods ($p = 4.19\times10^{-5}$) (Fig.1).

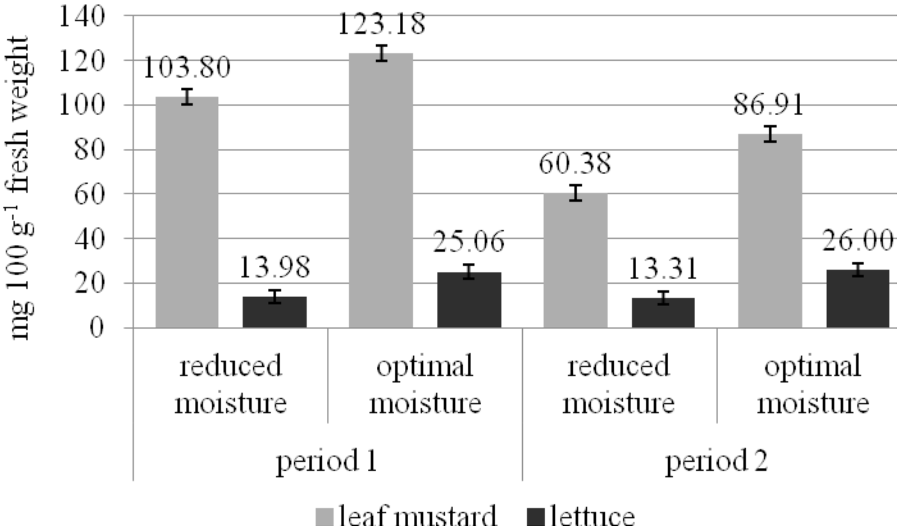

Figure 1. **Ascorbic acid content in lettuce and leaf mustard**

Higher content of vitamin C was observed in leaf mustard. Ascorbic acid content in the first growing period ranged between 103.8 and 123.18 mg 100 g^{-1} fresh weight. In the second growing period it was significant less than in the first growing period, it ranged between 60.38 and 86.91 mg 100 g^{-1} fresh weight. Vitamin C lettuce leaves contained three to seven times less ascorbic acid than leaf mustard leaves. Ascorbic acid content in lettuce leafs shows significant differences between irrigation variants ($p = 0.003$), but not significant differences between growing periods ($p = 0.93$). Ascorbic acid content in reduced moisture variant was two times less than in optimal soil moisture variant. In both periods vitamin C content in variant with reduced moisture and optimal moisture was practically identical.

Significant differences are not observed for antiradical activity in the lettuce and leaf mustard between both irrigation variants and growing periods (Fig.2).

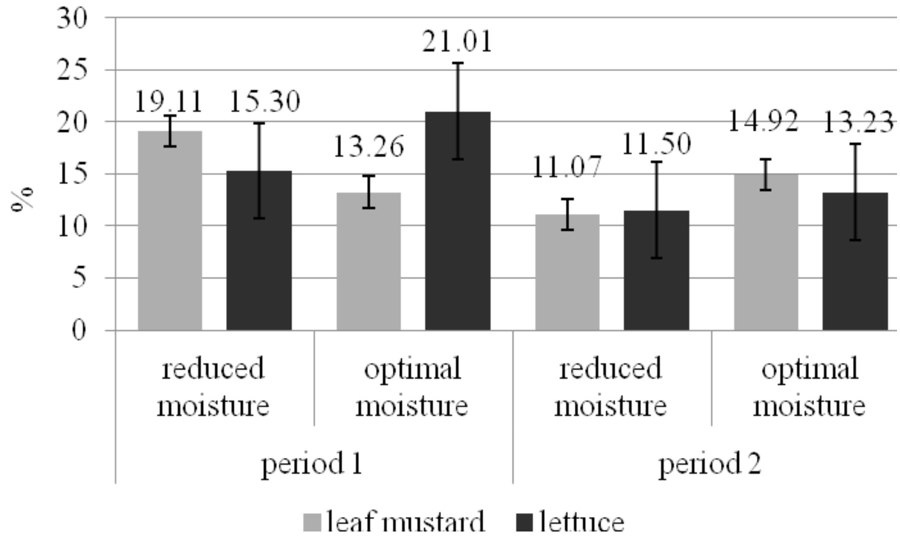

Figure 2. **Antiradical activity in lettuce and leaf mustard leaf**

Results of investigation did not show quite clear tendencies of antiradical activity changes in the lettuce and leaf mustard in two different growing periods and irrigations variants. In average for all samples antiradical activity was stated between 11.06 and 21.01%. If compare growing periods, in the first growing period for antiradical activity was observed tendency to be higher than in the second growing period.

Leafy vegetable production and consumption more and more interest growers because crop can be harvested several times during one vegetation period. Also our trial proved that it is possible to harvest leafy vegetables in Latvia even in September. Results obtained for vitamin C content are corresponding to those referred by

Cauni with colleagues, where content of ascorbic acid in lettuce in average was 24 mg 100 g^{-1} (detected by using titremetrical method) [1]. According to Liu and et al., in China vitamin C in lettuce leaves was in average 2.90 mg 100 g^{-1} fresh weight [14]. In our research vitamin C content in leaf mustard was higher than in lettuce leaves and ranged between 60.38 and 123.18 mg 100 g^{-1} fresh weight. Farnham with colleagues observed that vitamin C varied significantly among genotypes. In one variety content of vitamin C was 114 mg 100 g^{-1}, but in another – 162 mg 100 g^{-1} [15]. Other leafy vegetables also have high content of vitamin C. For example, vitamin C content in leafy parsley is 133 mg 100 g^{-1} and in celery leaves 85 mg 100 g^{-1} fresh weight [1].

C vitamin content depends on many factors, such as a cultivar, plant age, available photosynthetic radiation, soil type, indoor or outdoor culture [2]. Also in our research it was clearly observed that soil moisture and temperature influences content of ascorbic acid in leafy vegetables.

Obtained results are similar to findings of others in relation to the differences between growing periods. In USA were compared antiradical potential in lettuce when it was harvested in two different periods (July and September). In July it had higher antioxidant activity than in September [16]. Influence of growing conditions on the antiradical activity of leafy vegetables is reported also by Oh, et al. (2011), where higher antioxidant activity was found for vegetables grown under the open field conditions, compare to those grown in the high tunnels [9]. Our results indicates similar tendency that higher antioxidant activity was detected in better growing conditions – in the first growing period. In China it was stated that antioxidant activity was in average 39.57% in lettuce leaves and 21.80% in lettuce stems (by using DPPH assay) [14], which is higher than found in our investigations. In general, higher content of physiologically active compounds was observed in the first growing period with optimal soil moisture. Also irrigation influence on the leafy vegetables quality find in our trials is similar to findings of others. It is referred that irrigation increases leafy vegetables yield and quality. In Iran it was found that irrigation irrespective to water amounts used significantly increased mustard yield and quality, but the best results showed variants with higher water supply [11]. The same tendency was observed also for lettuce. The results investigation performed by Karam and colleague indicated that water stress caused by insufficient irrigation reduce leaf yield and quality [10].

In summary it can be concluded, that growing and management conditions (water supply, temperature, light conditions) directly influence biosynthesis of phytochemicals in plants. Growing conditions have effect on the quality of leaf vegetables, those influence leaf phenolic concentration and antioxidant activity. Our research does not confirm findings of Oh and colleagues, that leafy vegetable accumulate more antioxidants, if they are subjected to stress conditions [9]. Probably some particular stress conditions have positive influence on the changes of content of biologically active compounds, but they should be investigated more precisely in the agro–climatic conditions of Latvia.

CONCLUSIONS

Obtained results allow us to assume that water supply has influence on ascorbic acid content and antiradical activity of the leaf mustard and lettuce, but also other environment factors dependent on sowing period, such as temperature and light conditions can influence the amount of biochemical compounds in leafy vegetables. It is necessary to continue research about plant response on antioxidant and vitamin C accumulations in environmental stresses.

ACKNOWLEDGEMENTS

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MOLE DRAINAGE PERFORMANCE IN A CLAY LOAM SOIL

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Abstract. *Where soils are impermeable to depths of >2.5 m, the cost of a conventional drainage system to control the watertable is generally prohibitive because of the very close drain spacing needed. Under such circumstances a more viable option is to use drainage methods that incorporate soil disruption techniques. These include mole and gravel mole drainage. The success of mole drainage can be highly variable. The stability and long term effectiveness of mole drains depends upon the soil texture, stability of the soil aggregates to wetting and soil moisture status at the time of installation. This study was undertaken on a grassland farm dominated by clay loam and clay textured soils. The soil texture, combined with climate is not ideal for stable mole channel formation. While gravel mole drainage, designed for such situations could be prescribed for the site, the high cost makes this technique unattractive for landowners. National agricultural policy, driven by regional European policy, is placing pressure on such farms to increase productivity, so demand is rising for practical drainage solutions that can be implemented on farms with limited resources for investment. The objective of this study was to compare the effectiveness of mole and gravel mole drainage in removing excess water and controlling the watertable position from a soil with 35-45% clay content in the south of Ireland to determine the effectiveness of both treatments and establish whether the increased cost of the gravel mole drains can be justified in such a soil. Also the installation dates of mole drainage treatments were staggered (January versus July) to assess how soil moisture status during installation affected performance. The study site was poorly drained grassland (2.5 ha), with slope of 1.4% and perched watertable consistently < 1m below ground level (BGL). An open drain was excavated to 2 m BGL adjacent to the site to act as a collector drain for the drainage treatments. The experimental area was hydrologically isolated by a 1m deep ditch. Inside this area four blocks (60 m wide x 100 m long) were established. These were further sub-divided into four plots (15 m x 100 m). The experiment was laid out in a randomized complete block design with four replicates. The four treatments were: (A) no intervention, (B) mole drainage installed in January 2011, (C) mole drainage installed in July 2011 and (D) gravel mole drainage installed in July 2011. Mole drainage was installed at a depth of 0.55 m and spacing of 1.2 m (€291/ha), while gravel mole drainage was installed at a depth of 0.40 m and spacing of 1.2 m (€2816/ha). Rainfall (tipping bucket) and runoff and drain flow from each isolated plot (collection tanks and v-notch weirs) were measured continuously. Watertable depth was measured weekly. The response of treatments to rainfall was analysed for 12 events from June 2012 to March 2013. Data were analysed using ANOVA with treatment as a fixed effect. Both mole and gravel mole drainage were found to be effective in the removal of excess water off site. Drain performance varied between treatments and between events but general trends were evident: Drain flow from gravel mole drains had consistently higher peak flow rates and greater total flows than in other treatments. Therefore, gravel mole drainage was generally more effective than mole drainage in removing excess water. Mole and gravel mole drainage effectively lowered the watertable relative to the control during the experiment. The effectiveness of all drainage treatments deteriorated within the time frame of the experiment. During Event 1 (02/06/12) all drains performed well with high ratios of drain flow to effective drainage. From event 5 there was an increase in total runoff relative to drain flow. In event 6 (14/08/12) ratios of runoff to effective drainage in treatments B, C and D were 50, 41 and 41%, respectively (s.e. 5.9 %, NS), while the ratio of drain flow to effective drainage in the treatments was 4, 11 and 40% respectively, with treatment D outperforming both B and C (s.e. 6.5%, P<0.05). At event 10 (27/12/12) ratios of runoff to effective drainage remained high, while drain performance in all treatments was poor. This is attributed to rapid deterioration of soil macropores formed during mole drainage installation in persistent wet weather.*

Key words: *mole drainage, gravel mole drainage, drain flow, watertable.*

DIGESTED SLUDGES AS A SOURCE OF PHOSPHORUS, AND ENVIRONMENTAL RISK

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Abstract. *Digested sludge contains high amounts of phosphorus (P) and nitrogen (N) besides other macro and micronutrients. This study investigated the feasibility of recycling P from sludges originating from three Finnish water purification plants (Viikki, Vaasa, Jyväskylä) and from one dairy farm (Kalmari) into agricultural land by incubating sludges mixed with soil for 90 days. The digestates originating from water purification plants contained different types of waste water precipitation chemicals, whereas that from a dairy farm (Kalmari) contained none. The pH in all soil-sludge mixes decreased during the incubation compared with unfertilized and NPK treated soil. At 0, 30 and 90 days after incubation, the highest concentration of water-extractable or Mehlich-1 soluble P was in soil-Kalmari mix (untreated sludge) followed by the soil-NPK mix, while the lowest soluble P was in unfertilized soil and/or soil-sludge mixes containing precipitation chemicals. The concentration of Al-bound P and the sum of inorganic P fractions were highest in soil-Kalmari mixture. As for the other soil-sludge mixtures, the highest concentration of Al-bound P in soil was found in a mixture containing either Vaasa or Jyväskylä sludge with the highest concentration of Al-Pin the sludge. In addition, the activities of acid- & alkali-phosphatase enzymes increased during the incubation in sludge treated soils relative to unfertilized or NPK treated soil. The increase of P availability in sludge treated soils with time could be attributed to the increasing in the activity of acid-phosphatase, since this enzyme enhances P mineralization by attacking the phosphomonoester bonds of soil organic matter, and thus increasing the P availability for the micro-organisms and plants. The higher amounts of soluble P in soil with Kalmari sludge are more prone to leaching than the less soluble P forms in other sludges containing higher levels of Al or Fe bounded P.*

Key words: *digested sludge, phosphorus, recycling, environment.*

DEVELOPING A MOBILE LABORATORY METHOD FOR SOIL NUTRIENT ANALYSIS SERVICES TO LOW INCOME FARMERS

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Abstract. *We seek to develop a low-cost methodology for helping underprivileged farmers to analyse soil nutrients and select crops and soil enrichments relevant to their own field, by combining case-based reasoning (CBR) with dedicated image processing (IP) acquiring data from an antique but robust separation method, circular paper chromatography (CPC).*

In flows whose components tend to move at different speeds, particles sometimes aggregate into local streams of shared velocity; one example is the convection cells seen on the solar surface. This is especially apparent in radial flows, where increasing circumference permits migration patterns with more intricate lateral detail to evolve. We have defined a CPC procedure in which this will occur consistently. Each soil sample is dried, sieved through 2mm mesh, and orbitally agitated in 1% NaOH. The suspension is separated with conventional CPC by wick-feeding to a filter paper prepared with $AgNO_3$ *as indicator.*

In CBR, the number of input values must exceed the desired number of output values. From each optically scanned CPC, the IP extracts 153 area, shape and hue parameters which the CBR compares with our database of 30000 samples previously analysed in conventional soil laboratories. The farmer receives a print-out showing eighteen soil parameters and recommendations for suitable crops and soil enrichments.

The entire operation can be housed in a small bus and operated in rural areas by two relatively low-educated staff after appropriate training, producing about fifty analyses per working day.

Characteristically, CBR neither requires nor generates theoretical explanations; it only delivers results. Our current research involves pilot field expeditions and improving correlations with conventional analyses by optimising the weighting coefficients in the IP-CBR interface. Current soil parameter values are within ±10% of conventional values, except for organic carbon ±30%, sulphur ±28% and zinc ±20%.

We would welcome tests of our methodology in non-Indian environments.

Key words: *Soil nutrient analysis, Crop recommendations, Circular paper chromatography, Image processing analysis, CPC evaluation.*

ESTABLISHMENT AND GROWTH OF CHICORY (*CICHORIUM INTYBUS*) UNDERSOWN IN CONVENTIONALLY CROPPED CEREALS

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Abstract. *Chicory is suitable as an undersown catch crop for several reasons, but establishment in conventional cropping systems is often unsatisfactory. This project examined establishment of chicory undersown in conventional cereals. Field trials were performed in summer barley and winter wheat, combined with evaluations of tests conducted by practical farmers in their fields (seven fields of cereals). In summer barley, early sowing on the soil surface followed by rolling (ESR) gave more chicory plants and more biomass than early sowing with seed incorporated with coulters or late sowing on the surface. With ESR as sowing method, weed harrowing gave the best results for chicory establishment and biomass (34 plants m^{-2} and 1520 kg fresh weight ha^{-1}) and an equivalent weed effect to herbicides. Harmony Plus was the most selective herbicide and Starane XL, Hussar and Legacy were the least selective. After winter wheat, number of chicory plants and amount of biomass in October were greater when herbicides (Baccara or Lexus WG + Boxer EC + Legacy) were used only in the autumn. After summer barley, chicory biomass in October was deemed too low to achieve the desired effect on N losses, soil structure and improvement of soil organic matter except on one farm, in an irrigated winter barley field where chicory was undersown in early April and herbicides were only used in autumn (2.1 tonnes chicory dry matter ha^{-1}). Therefore further research should focus on these conditions. Another conclusion was that combining a few field trials with evaluation of tests carried out by farmers in their own fields can increase knowledge faster than working with field trials alone.*

Key words: e*stablishment, chicory, undersown, cereals.*

INTRODUCTION

Chicory has been found to be suitable as undersown catch crop because it does not reduce yield of the cereal main crop but grows fast in autumn after cereal harvest [1],[2]. It is more effective in capturing nitrogen (N) from leaching than ryegrass because the roots penetrate further into the soil (2.5 m compared with 1 m for ryegrass [3]) and provides fast return of plant-available N to the next crop [4]. Chicory has, at least as a perennial crop, also been proven to improve structure, e.g. four years of chicory gave a better pre-pre-crop effect than red clover and alfalfa leys in a compacted soil [5]. Chicory is easy to establish when undersown in organically grown cereals, but in conventional cropping establishment is often unsatisfactory. The aim of this project was to examine establishment of chicory undersown in conventional cereals.

MATERIALS AND METHODS

Establishment of chicory (seed rate 4 kg ha^{-1}) was studied in field trials in spring barley with a split block design [6], with four blocks, three establishment methods in columns and 12 weed control methods in rows. Establishment methods were: early sowing on the surface followed by rolling (ESR), early sowing with seed incorporated with conventional seed coulters (ESI) and late sowing on the surface (LS). Dates for sowing were 6 May in ESR and ESI (26 days after sowing of barley [DAS]) and 16 June in LS (57 DAS; cereal development stage, decimal code (DC) 37). The weed control methods were: untreated control, weed harrowing at DC 13 (2 May) and 10 regimes with chemical herbicides applied on 7 May.

Two more field trials with chicory undersown in winter wheat were performed in trials originally designed for examining control of common windgrass (*Apera spica-venti*) and dicot weeds. Furthermore tests carried out by five commercial farmers, using a strip design without replicates in their practical fields, were evaluated. In these farmers' tests, chicory was undersown (rate 4 kg ha^{-1}) in seven fields of cereals: spring barley (1), winter barley (1), winter wheat (2), winter rye (2) and triticale (1). There were no weed harrowing treatments for comparison in the winter wheat field trials or the farmers' tests.

RESULTS AND DISCUSSION

ESR gave the highest number of chicory plants (34 chicory plants m^{-2}; p<0.01) and largest amount of biomass (1.5 t ha^{-1} of fresh biomass ≈ 150 kg dry matter (DM) ha^{-1}; p<0.01) at the end of October (64 days after harvesting of barley) (Table 1). However, in 22 previous Swedish trials with undersown ryegrass as a catch crop in summer barley, the aboveground biomass was 1040 kg DM ha^{-1} [7], i.e. seven-fold the amount we achieved in the field trial with chicory undersown in barley. Weed harrowing gave the best results for chicory establishment and an equivalent weed control effect to herbicides.

In the rows without weed control there were 13 plants m^{-2}, in the weed harrowed rows 35 plants m^{-2} and in the rows with chemical herbicides 3-18 plants m^{-2}. The higher number of plants in weed harrowed plots compared with the untreated control and also compared with the herbicide treatments indicates that the positive effect of improved seedbed conditions obtained by weed harrowing overshadowed the negative effects of herbicides on survival of plants. However, the fewer plants in the other treatments compared with weed harrowing were partly compensated for by faster growth per plant, resulting in biomass only being significantly lower with chemical weed control by Starane XL, Hussar and Legacy compared with the weed harrowing treatment. In the Harmony Plus plots, the number of chicory plants was not significantly reduced compared with weed harrowing, but biomass was 25% lower (difference not significant).

Table 1

Summary of one-way ANOVA results for the establishment method of early sowing on the surface followed by rolling (ESR). Number of chicory plants, biomass (fresh weight) and weed cover on 16 October (barley harvested 13 August). Values within columns followed by different letters are significantly different (P<0.05; Tukey's test)

Weed control: Dose, method	Chicory plants No. m^{-2}	Chicory plants g m^{-2}	Weed cover (0-100)
Untreated	13.0 b	84.0 ab	10.5 a
Weed harrowed, DC 13	34.5 a	152.5 a	5.0 b
2 Ariane S[1]	5.0 b	42.0 ab	6.2 ab
1 Starane XL[2]	3.0 b	19.5 b	5.0 b
12 g Express 50 SX[3]	11.5 b	96.5 ab	5.2 b
100 g Hussar[4]	4.0 b	19.5 b	5.5 ab
1,5 MCPA[5]	8.0 b	57.0 ab	6.8 ab
15 g Gratil 75 WG[6]	6.5 b	46.0 ab	5.5 ab
0.4 Starane 180[7]	8.0 b	46.5 ab	5.5 ab
75 ml Primus[8]	12.5 b	84.5 ab	4.8 b
15 g Harmony Plus[9]	17.5 ab	114.5 ab	5.8 ab
0.15 Legacy[10]	7.0 b	26.0 b	5.8 ab
P-value	0.000	0.009	0.042
Tukey's HSD	19.1	120.7	5.2
R^2 (%)	73	66	72
R^2 adjusted (%)	58	51	60
SEM	3.8	24.3	1.0
CV, %	71	74	35

Active substances: concentration in g/L, g/kg or %: 1) MCPA + klopyralid + fluroxipyr (200 + 20 + 40g); 2) Fluroxipyr + florasulam 100 + 2,5 g; 3) Tribenuron methyl 50 weight-%; 4) Iodosulfuron (50 g); 5) MCPA (750 g); 6) Amidosulfuron (75 weight-%) ; 7) Fluroxipyr (180 g); 8) Florasulam (50 g L^{-1}); 9) Tribenuron methyl + thifensulfuron methyl (17 + 33 weight-%); 10) Diflufenican (500 g)

In the field trials in winter wheat, chicory had most plants and biomass when herbicides were used only in the autumn (1.25 Baccara or 50 g Lexus WG + 1.5 Boxer EC + 15 g Legacy + surfactant), although Harmony

Plus had acceptable selectivity for chicory (results not shown; for details see [8]). Early sowing of chicory in the spring was an advantage compared with waiting until after the chemical weed treatments in the spring. In the best treatments in winter wheat, the number of chicory plants was equivalent to that achieved with the best treatments in summer barley. The biomass was less than half that in summer barley, but the measurements were made in late August-early September and should therefore not be compared with those in barley, which were made on 16 October.

Farmers' field tests indicated that undersowing of chicory in spring barley higher than 15 cm gave poor establishment of chicory. These tests also showed that a good water supply was important for the ability of the chicory seedlings to compete with the cereal plants.

Of all field trials and farmers' tests, chicory achieved the greatest biomass in October (2.1 t DM ha^{-1}) in a farmer's test field with winter barley where the chicory was sown with disc coulters in early April in good soil moisture conditions, the barley crop was irrigated and the barley was harvested early. Herbicides were only used in the autumn (1.7 Boxer + 0.7 Baccara). According to the farmer, the barley was relatively weak in spring but the yield was good.

CONCLUSIONS

In spring barley field experiment:

– early sowing followed by rolling (ESR) in combination with weed harrowing gave the best results for chicory establishment and growth and an equivalent weed control effect to the best herbicide regimes
– Harmony Plus was the most selective herbicide and Starane XL, Hussar and Legacy were the least selective.

Chicory biomass in October after barley was deemed too low to give the desired effect on N losses, soil structure and improvement of soil organic matter. The only exception to this was in a farmer's test in an undersown in the beginning of April and herbicides were only used in autumn. Therefore further research should irrigated winter barley field, where chicory was focus on these kinds of conditions.

Another conclusion was that combining a few field trials with evaluation of tests carried out by farmers in their own fields increased knowledge faster than working with field trials alone.

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SOIL PHOSPHOROUS AND POTASSIUM APPARENT RECOVERY BY FIELD CROPS

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Abstract. *Data from 72 field trials using the same layout was carried out in four locations in Latvia during 2008-2012 was used. Experimental crops: winter and spring wheat, winter rye, winter and spring rape, spring barley and potatoes. In each experiment soil before planting of crops was tested in two depths: 0-20 cm and 20-40 cm and plant available phosphorous and potassium (Egner-Riehm method) was determined. Using data of bulk density, PK content was transformed on 0-20 and 0-40 cm soil layer and expressed as tons per ha. Apparent recovery of soil PK (soil PK recovery efficiency) was calculated as the difference in PK uptake in plots not receiving fertilisers and PK content in the soil (kg ha^{-1}) within the depth of 0-20 or 0-40 cm and expressed as a proportion of these two values. It was found that soil phosphorous apparent recovery in average consisted as 8.68% if calculated based on 0-20 cm soil layer or 4.96% – if calculated based on 0-40 cm soil layer and has small differences depending on crops. Soil potassium recovery was significantly different depending on crops. In average cereals and rape utilised 12.76% from its content in 0-20 cm soil layer or 6.79% from content in 0-40 cm soil layer. Potatoes – 62.04% and 32.81% subsequently. It is possible to use the developed soil phosphorous and potassium recovery factors for fertilising planning in situations where PK containing fertilisers are used regularly and residual effect of its is applications is prospective.*

Key words: *fertiliser recommendations; plant nutrient utilisation; soil fertility tests.*

INTRODUCTION

The effective use of nutrients is the main goal for fertiliser use planning. Additionally nitrogen and phosphorous management has a great environmental concern. Soil is the primary source of nutrients for crops and therefore assessment of its nutrient supplying power has a great interest. Nutrient pool, its availability, abiotic and biotic factors regulating plant nutrient uptake by crops are the topics having importance for research and practical farming. As normally crops utilise only part of nutrients applied by fertilisers, some accumulation of low mobility ones like phosphorous and potassium under periodical fertilisation could happen. These nutrients might have the certain positive residual effect on the next crops and therefore could be taken into account in fertiliser planning.

Investigations done by several authors concerning phosphorous availability reveal that phosphates in the soil are deposited on solid particles by help of adsorption, absorption and chemical reactions [2-3]. Phosphorous is fixed on the surface on clay particles, carbonates, Fe and Al oxides or incorporated into its structure. Fixation energy could differ due to the composition of solid phase and therefore desorption processes might be different, some part of phosphates are more mobile and are able to return back in the soil solution, another part – are more immobile. Plant available soil phosphorous is crop limiting factor only below the certain critical level and therefore not always are necessary to return back amount off-taken by yield annually [2-3]. Building up the soil phosphorous using increased rates of fertilisers not always is the best way of farming strategy. Probably it is better to define some optimum soil phosphorous (as well as potassium) range in which moderate annual PK applications could provide crops with nutrients.

The main purpose of this publication is to discuss about the possibility of crops to utilise the soil phosphorous and potassium under its annual applications and to access the soils' PK apparent recovery.

MATERIALS AND METHODS

Data from field trials carried out in 2008-2012 was used. All together 72 field trials using the same layout was carried out in four locations of Latvia – Peterlauki (56º 32′, 23º 43′), Priekuli (57º 18′, 25º 20′), Vecauce (56º 28′, 22º 52′) and Stende (57º 11′, 22º 33′). The experiments were laid out in a randomised complete block design at each site with four replicates of each treatment. Plot size 20-25 m^2 (depending on crop). In each trial 9 fertilising treatments were compared but for this publication only plots not receiving fertilisers were used. After harvesting yield of main product and by-product was accounted and phosphorous and potassium in content the yield was determinate. Taking into consideration this values, PK uptake was calculated (the main product plus by-product without postharvest residues).

Soils in experimental sites were typical for Latvia agricultural land. In Peterlauki *Endoprotocalcic Chromic Stagnic Luvisol* (*Clayic*, *Cutanic*, *Hypereutric*), silty clay loam/clay; in Priekuli *Endoeutric Endoluvic Stagnosol* (*Drainic*, *Loamic*), fine sandy loam; in Vecauce *Calcaric Luvic Endostagnic Phaeozem* (*Protoanthric*, *Loamic*), sandy loam/loamy sand and in Stende *Eutric Stagnic Retisol* (*Cutanic*, *Drainic*, *Loamic*), sandy clay loam (WRB, 2014) [3]. Every year before establishment of experiment, soil sampling was done and following parameters were analysed for the depth of 0-20, 20-40 and 40-60 cm of topsoil: pH in 1 *M* KCl suspension, plant available phosphorous and potassium (Egner-Riehm method), organic carbon (Tyurin's method). For transformation of soil organic carbon data to soil organic matter (SOM), Van Bemmelen factor – 1.724 was used. Soil density and field water capacity was also determinate for every depth of soil (undisturbed sample saturation in 100 mL steel cylinders). Using data of bulk density, PK content was transformed on 0-20 and 0-40 cm soil layer and expressed as tons per ha. Apparent recovery of soil PK (soil PK recovery efficiency) was calculated as the difference in PK uptake in plots not receiving fertilisers and PK content in the soil (kg ha^{-1}) within the depth of 0-20 or 0-40 cm and expressed as a proportion of these two values.

For data processing standard methods of descriptive statistics (correlation, variance, *t*-test) was used.

RESULTS AND DISCUSSION

Soil fertility characterization is given in Table 1. As experimental plots were located in the different fields annually, parameters differ. In most cases soil phosphorous and potassium level is medium to high or very high according rating used for soil fertility tests in Latvia. These soils are periodically receiving phosphorous and potassium fertilisers and are not nutrient depleted. Therefore the further discussion will be only for situation, when crops were not treated with PK fertilisers for one year (one growing season) but not for the long time.

Table 1

Soil properties in experimental sites

Location	pH KCl	Soil organic matter, %	P_2O_5	K_2O
			mg kg^{-1}	
0-20 cm				
Peterlauki	6.6-7.2	1.9-3.1	102-240 (M/H)*	153-295 (M/H)
Priekuli	4.6-6.3	1.9-3.1	115-258 (M/VH)	93-232 (M/H)
Vecauce	6.3-7.3	1.9-2.7	133-391 (H/VH)	90-240 (M/H)
Stende	5.3-6.7	1.9-2.7	83-251 (M/VH)	126-189 (M/H)
20-40 cm				
Peterlauki	6.6-7.4	1.3-2.6	59-171 (L/H)	119-256 (M/H)
Priekuli	4.6-6.3	1.5-2.3	65-191 (M/VH)	102-260 (M/H)
Vecauce	6.4-7.2	1.8-2.3	122-374 (H/VH)	86-220 (M/H)
Stende	5.2-6.4	0.9-2.3	59-208 (L/VH)	101-178 (M/H)

* **Note:** in parenthesis – nutrient value: L – low, M – medium, H – high and VH – very high.

Crop yield and PK uptake by crops' yield is shown in Table 2. Yield data are given in two columns – A plots not receiving any fertilisers, or "pure zero", but column B – plots received PK fertilisers but without nitrogen. Data shows, that there were very little yield increase due to PK fertilisation if the nitrogen was absent. One year PK fertiliser lack was not the limiting factor for plant growth. Crops' yield obtained in experimental plots was comparatively high taking into consideration that nitrogen fertilisation was not applied.

PK uptake by yield is given for situation when no any fertilisers were used for crops, e.g. "pure zero". Share of soil for providing crops nutrient requirements is rather considerable. This type of plant nutrient uptake could be rather referred as biological uptake, e.g. nutrients necessary to be absorbed by plants during the vegetation. Only share of PK in roots and stubble is absent. Normally by-products of potatoes and rape always are left on the field but straw of cereals – depending on farmers needs. This type of plant nutrient uptake does not show exactly that part of nutrients, which is removed from field due to the commercial activity. These values depend on farming practice, which could differ year by year.

Table 2

Crop yield and phosphorus and potassium uptake by main and by-product

Crop	Location	Yield, t ha^{-1}			Uptake by yield, kg ha^{-1}	
		main product**		by-product		
		A	B	A	P_2O_5	K_2O
Winter wheat	Peterlauki (8)*	5.03	5.19	7.55	48.86	96.44
	Stende (8)	5.85	6.14	4.85	52.40	67.03
Spring wheat	Peterlauki (5)	3.85	4.01	4.52	46.17	49.34
	Stende (3)	3.32	3.47	4.16	47.70	53.08
Rye	Priekuli (7)	3.76	4.14	3.93	39.51	51.06
	Stende (8)	5.52	5.97	5.81	55.48	88.64
Spring barley	Peterlauki (5)	3.79	3.97	3.03	38.95	49.78
	Priekuli (3)	2.74	2.90	2.89	29.11	39.71
	Stende (3)	3.22	3.07	2.14	34.23	36.07
Winter rape	Peterlauki (4)	2.88	2.81	5.02	48.04	82.41
	Vecauce (4)	2.15	2.23	4.52	47.83	87.63
Spring rape	Peterlauki (3)	1.36	1.40	3.02	29.09	44.66
	Vecauce (3)	1.37	1.54	3.56	34.38	50.55
Potatoes	Priekuli (8)	31.10	31.75	12.40	42.31	252.06

Note: * in parenthesis – number of trials;
** column A – plots not receiving any fertilisers,
column B – plots receiving only PK fertilisers.

Soil phosphorus and potassium apparent recovery was calculated in two ways – only for topsoil (0-20 cm) and for all depth to the 40 cm (Table 3-4). Normally the second assumption is more reasonable for crop root distribution and therefore for plant nutrient absorption. But in soil fertility tests usually only top 20 cm is sampled and analysed considering that so called plough layer is more or less homogenous as a result of periodical mixing. In Latvia situation this tillage layer usually is somewhere between 25 to 30 cm deep, deeper than 0-20 cm layer but more shallow as 0-40 cm. For practical purposes the use of topsoil (0-20 cm) data is fully acceptable.

Soil phosphorous recovery was at the range from 4.11 to 12.37% if calculated on the 0-20 cm soil layer basis. There is not so important crop influence compared with soil type, if it is grouped according to the WRB principles. Spring wheat was able to recover from *Luvisol* 11.74±2.84% of phosphorous but only 6.59±4.08% from *Retisol*. *Retisol* and *Stagnosol* was also less providing phosphorous source for spring barley, but *Phaeozem* – for winter rape.

Soil potassium apparent recovery was higher – from 6.45±3.24% to 20.13±6.11%. Very high it was for potatoes – 62.04±13.17% because this element has high concentration in both parts of yield – in tubers as well as in leaves. There was a small difference in soil potassium recovery taking into consideration soil type. Only for spring rape recovery rate from *Phaeozem* was significantly higher compared with *Luvisol*.

Analysis of variance showed that there were not significant differences in phosphorous and potassium recovery from the soil by winter wheat, rape and potatoes depending on location of experiment, crop variety and meteorological conditions of year. For rye significant impact was observed only by year conditions.

Table 3

Soil phosphorous apparent recovery, %

Crop	Soil	Apparent recovery, %			
		0-20 cm		0-40 cm	
		mean	standard deviation	mean	standard deviation
Winter wheat	*Luvisol*	11.88	1.63	6.95	0.97
	Retisol	11.28	6.40	6.56	3.64
Spring wheat	*Luvisol*	11.74	2.84	6.92	2.32
	Retisol	6.59	4.08	3.48	1.58
Rye	*Stagnosol*	7.93	4.30	4.32	2.47
	Retisol	12.37	7.51	6.21	3.55
Spring barley	*Luvisol*	9.86	3.54	5.73	2.42
	Stagnosol	4.60	0.14	2.82	0.25
	Retisol	4.11	0.54	2.28	0.14
Winter rape	*Luvisol*	10.13	5.08	6.03	2.96
	Phaeozem	5.93	1.27	3.24	0.76
Spring rape	*Luvisol*	5.34	3.24	3.22	1.43
	Phaeozem	5.76	2.73	2.99	0.20
Potatoes	*Stagnosol*	10.06	1.56	6.11	0.82

Table 4

Soil potassium apparent recovery, %

Crop	Soil	Apparent recovery, %			
		0-20 cm		0-40 cm	
		mean	standard deviation	mean	standard deviation
Winter wheat	*Luvisol*	17.86	6.96	10.11	3.92
	Retisol	14.82	3.51	7.75	1.91
Spring wheat	*Luvisol*	9.16	2.98	4.81	2.43
	Retisol	8.24	0.76	3.84	0.08
Rye	*Stagnosol*	12.81	5.50	7.01	3.13
	Retisol	20.13	6.11	10.25	3.63
Spring barley	*Luvisol*	7.51	3.82	4.59	1.36
	Stagnosol	6.46	1.31	3.49	0.89
	Retisol	6.52	2.15	3.00	0.66
Winter rape	*Luvisol*	15.28	8.09	8.66	4.49
	Phaeozem	18.17	3.10	9.51	1.21
Spring rape	*Luvisol*	6.45	3.24	3.79	2.03
	Phaeozem	16.54	2.30	8.32	1.20
Potatoes	*Stagnosol*	62.04	13.17	32.81	5.10

As it is important for practical purposes to assess the soil phosphorous and potassium supplying potential from the topsoil, some calculations of correlation between PK content in soil and its apparent recovery was done (Table 5). In average the correlation was higher for soil phosphorous with exception for potatoes, compared with soil potassium. High correlation of these parameters for potassium was for spring rape, winter rape and potatoes.

Table 5

Correlation between PK content in 0-20 cm and apparent recovery

Crop	Phosphorous	Potassium
Winter wheat	-0.81	-0.10
Spring wheat	-0.81	-0.36
Rye	-0.71	-0.40
Spring barley	-0.67	-0.58
Winter rape	-0.86	-0.74
Spring rape	-0.63	-0.98
Potatoes	-0.48	-0.70
All crops, average	**-0.67**	**-0.41**

Average values of soil phosphorous and potassium apparent recovery by certain crop and also for all crops are given in Table 6. These values could be used for practical purposes in fertilising planning depending on methods of soil testing – only for 0-20 cm or for 0-40 cm depth. There was small difference in phosphorous recovery if to include all the crops in one single average value, or to separate values between cereals, rape in one hand and potatoes on the other hand. But such distribution is important for assessment of soil potassium recovery values.

Table 6

Soil phosphorous and potassium apparent recovery, % (average values)

Crop	Phosphorous		Potassium	
	0-20 cm	0-40 cm	0-20 cm	0-40 cm
Winter wheat	11.58	6.76	16.34	8.93
Spring wheat	9.17	5.20	8.70	4.33
Rye	10.15	5.27	16.47	8.63
Spring barley	6.19	3.61	6.83	3.69
Winter rape	8.03	4.64	16.73	9.09
Spring rape	5.55	3.11	11.50	6.06
Cereals, rape	**8.45**	**4.77**	**12.76**	**6.79**
Potatoes	10.06	6.11	62.04	32.81
All crops, average	**8.68**	**4.96**	**19.80**	**10.51**

CONCLUSIONS

Soil phosphorous and potassium pool is important source for crops' PK requirement and its apparent recovery factors could assess the share of these recourses for plant nutrition.

It is possible to use the developed soil phosphorous and potassium recovery factors for fertilising planning in situations where PK containing fertilisers are used regularly and residual effect of its is applications is prospective.

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BIOECONOMY

ENERGY CROPS AND SUSTAINABILITY – DEVELOPMENT OF AN EVALUATION MODEL

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Abstract. *Demand for bioenergy crops from arable land is likely to increase in the future, and there is a need to verify their sustainability. In sustainability assessment many different factors must be considered, including social, economic and ecological/environmental aspects. We have developed a model to evaluate the sustainability of bioenergy crop cultivation. The focus of this study was to illustrate and evaluate the model's usefulness. The model was therefore developed only to a limited extent where a few criteria are selected and only willow cultivation in Götaland northern plains in Sweden is evaluated. The model is aimed for local authorities, to function as decision support. The model evaluates the greenhouse gas emissions, energy balance, nitrogen leaching together and the impact on the landscape. For the impact on the landscape a scoring system was developed to make it quantifiable and thus possible to evaluate along with the other criteria. The model was tested in a case study on a willow cultivation, with winter wheat and ley as reference crops. The model proved to be a good basis for evaluation of sustainability in the cultivation of energy crops. The graphical presentation of the model result clearly showed how the different crops perform in the included criteria. We however conclude that the model needs to be extended and refined before it can function as a basis for choice between different crops or location sites.*

Key words: *Bioenergy, willow, sustainability, model, landscape.*

INTRODUCTION

Demand for bioenergy crops from arable land is likely to increase in the future. Energy crops should contribute to sustainable development. In sustainability assessment many different factors must be considered, including social, economic and ecological/environmental aspects.

In this project, we have developed a model that can be used to quantify and graphically visualize different aspects of sustainability when cultivating energy crops. The focus of this initial project was to illustrate and evaluate the model's usefulness. The model is therefore developed only to a limited extent where a few criteria are selected and only willow cultivation in Götalands norra slättbygder (Götaland northern plains) is evaluated. The model is aimed for local authorities, to function as decision support. In cooperation with a reference group, four sustainability criteria were selected; (1) greenhouse gases, (2) nitrogen leaching, (3) energy balance and (4) impact on the visual landscape character. The model was tested in a case study, comparing willow with two reference crops, winter wheat and cultivated grassland (ley).

MATERIALS AND METHODS

The first three criteria are quantifiable and were calculated using life cycle assessment methodology. The system boundary is at the field edge, which means that the use of the crop is not included. For greenhouse gases, emissions of carbon dioxide, methane and nitrous oxides were included from all processes upstream (e.g. production of fertilizers) and from the field based on data in [1]. The energy balance was calculated as the ratio between primary energy input and higher heating value energy content in the produced crop. For nitrogen leaching, average data from Johansson and Mårtensson [2] was used, which is data based on modelling of leaching for different crop and soil types, combined with statistics on yields, nitrogen fertilization levels as well as weather data. For further explanation of input data, see Gunnarsson et al. [3].

The fourth criteria, impact on the visual landscape, which by the reference group was judged to be a key issue to address if an expansion of willow cultivation is to take place, is more difficult to quantify, and a framework for the evaluation needed to be developed. The new framework is based on Lynch [4] who was a pioneer in evaluation of city landscape structures. The framework we have developed consists of five questions that focus on visual impact, where each question is assessed according to the scale small impact (1 point), medium impact

(2 points) and large impact (3 points). The questions include field size, impact on landscape topography, impact on paths in the landscape, impact on individual elements and impacts on scenery and horizons. The reference crops wheat and ley were assumed to have small impact on the visual landscape, and given the highest (most positive) score.

The four selected criteria were normalizing according to min-max methodology on a scale between 0 and 1, where 1 is the best value and 0 the worst value. The best and worst value for each criterion was selected based on the best and worst crop in the region, which were different crops for each criterion. Impacts of the selected criteria for all crops in the region were based on same methodology as described above, and regional statistics.

RESULTS AND DISCUSSION

The model was tested in a case study on a willow cultivation in the northern plains of Götaland (Figure 1). The willow field is 3 hectares, fertilized with sewage sludge and mineral nitrogen, with a yield of 12 500 kg dry matter per hectare and year. The soil type is clay loam. As a reference, cultivation of ley and winter wheat on the same field was also put into the model.

Figure 1. **Overview of the case study area in the northern plains of Götaland**

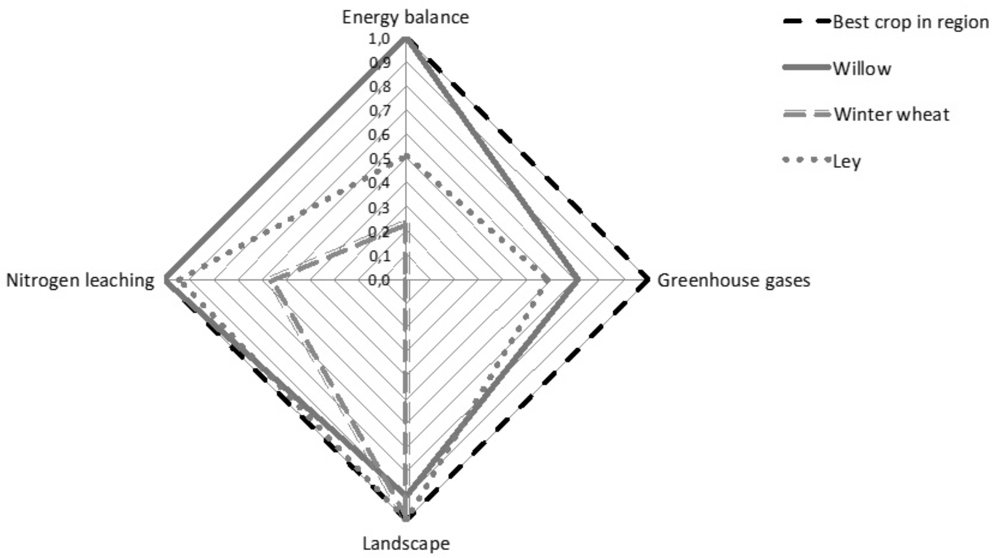

Figure 2. **Case study model results for willow, winter wheat and ley cultivated on a field in the northern region plains of Götaland in Sweden, impact per hectare for different criteria. Maximum score (best crop in region)=1, minimum score (worst crop in region)=0.**

In the case study, willow turned out better than the reference crops for the criteria energy balance, greenhouse gas emissions and nitrogen leaching, but willow had worse results for the landscape criteria (Figure 2). Preference of one crop over the other may of course depend on the choice of criteria, had other criteria been selected the assessment could have another outcome.

Willow gets worse results for the greenhouse gas criteria than one might have anticipated; this is due to emissions from the production of nitrogen fertilizers and emissions of nitrous oxide from soil. This result is when we calculate per hectare. As the willow has a relatively high yield, the results would be different if calculated per kg of crop. Winter wheat gets poor results, especially for greenhouse gases, it is one of the worst crops to grow on this field according to the model since it has high application rates of nitrogen fertilizers.

Impact on the landscape is relatively small in all cases, which may be due to the case study farm being a plain where the field is the same size as the surrounding fields and that no specific paths, views or horizontal lines are affected. The good results could also be an outcome of the developed method and there is a need to adjust and validate the model by testing it on other cultivation sites.

For the energy balance, the studied willow field scored best of all crops in the northern region plains of Götaland, due to the high yield and low energy input. The reference crops ley and winter wheat had an average or lower score compared to willow.

The nitrogen leaching was lowest (had the highest score) for willow, closely followed by ley. Winter wheat ha a much higher nitrogen leaching, but lower than the worst crop (spring barley) in the northern region plains of Götaland.

CONCLUSIONS

The model developed in this project evaluates the quantitative criteria greenhouse gas emissions, energy balance and nitrogen leaching together with the qualitative criterion impact on the landscape. For the impact on the landscape a scoring system was developed to make it quantifiable and thus possible to evaluate along with the other criteria. The model proved to be a good basis for evaluation of sustainability in the cultivation of energy crops. The graphical presentation of the model result clearly showed how the different crops perform in the included criteria.

Should the model be developed so that more criteria, cultivation areas and energy crops are included, the model could serve as a basis for selection of crops or choice of cultivation site. For development of an overall assessment, economy and biodiversity would be relevant sustainability criteria to include. Farmers and farm advisors could then be both users of the model and the model results.

As with all crop models, the results were found to be sensitive to different assumptions, for example about the yield and fertilization. The evaluation is also affected if the results are calculated per hectare or per kg crop; crops with high yields generally perform better calculated per kg crop.

Another conclusion from the project is that sustainability assessments are complex, and more development of the model is needed in terms of scope and method to provide a broader and more nuanced picture of the impact on sustainability. The number of criteria as well as the number of energy crops needs to be expanded. The calculation of the individual criteria can be refined, in particular the evaluation of the impact on the landscape. Also the normalization and visualization of the result can be improved.

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BIOMASS AND ENERGY PRODUCTIVITY OF DIFFERENT PLANT SPECIES UNDER WESTERN LITHUANIA CONDITIONS

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Abstract. *Long-term field experiments with different perennial crops were held in Western Lithuania, during 2009-2012. The field trials were composed as two factorial design with the aim to investigate the effect of liming and N fertilization on crops biomass and energy productivity. The soil of the experimental site is naturally acid moraine loamy (Bathygleyic Dystric Glossic Retisol), pH 4.2-4.4.*
Out of seven energy crops, common osier reached the highest annual dry mass (DM) yield and highest energy output (GJ ha^{-1}). Similarly, cup plant DM yield and energy output had superiority over other non-conventional crops as well as reed canary grass – among the perennial grasses. Both, liming and N fertilization had a positive impact to black poplar, cup plant, virginia mallow and cocksfoot productivity. Meanwhile the increase in common osier, common mugwort and reed canary grass DM yield and energy output was basically determined by N fertilization; whereas the role of liming was insufficient in most cases.

Key words: *perennial crops, liming, nitrogen, yield, energy.*

INTRODUCTION

Biomass is very important renewable energy source. In compare with fossil fuels, plant-based biofuel could significantly reduce the greenhouse effect; since CO_2 emissions are approximately equal to zero, since there is approximately no net contribution of carbon to the biosphere [1].
Some authors emphasize that perennial plants have superiority over annuals due to higher energy potential, less expenses for cultivation and higher production profitability [2],[3]. In recent years, in Lithuania as well abroad, the greatest attention is focused on the species, which have high biomass potential which could be successfully applied for biofuel purposes.
Utilization of biomass for energy production is determined by the chemical composition, i.e., carbon, hemicellulose, starch, sugar, oil concentration and the like. Basic requirements for energy crops are the following: 1) high yield with maximum energy output; 2) low energy input to produce; 3) low cultivation costs; 4) chemical composition with the least contaminants; 5) low nutrient requirements [4].
Some short rotation forest plants (particularly *Salix* or *Populus* species) are widely cultivating in Denmark, Poland and other temperate climate countries [5]. The trials hold in Eastern Lithuania shows that some modern varieties could produce up to 87,0-90,7 t ha^{-1} DM per one 3-4 years rotation [6].
Cup plant (*Silphium perfoliatum* L.) and virginia mallow (*Sida hermaphrodita* Rusby) are introduced species in Lithuania and are originated from Northern America. The scientific interest to both species as energy crops is gradually increasing. Many years cup plant was investigated as ornamental, melliferous and fodder crop [7]. There are some suggestions that cup plant could be grown as energy crop and its biomass used for bioenergy purposes [8]. The majority of experiments with virginia mallow were done by Polish researches. In dependence on soil type and other biotic and abiotic factors, virginia mallow DM yield is varying from 9 to 19 t ha^{-1} DM [9].
Out of perennial crops, reed canary grass (*Phalaris arundinacea* L.) is a promising bio-energy crop, but its productivity is uneven and depends on many factors [10],[11]. Altogether, there is a lack data the tolerance of the crop to different soil pH levels. Cocksfoot (*Dactylis glomerata* L.) received less attention as an energy crop so far. However, there are some data that the species positively reacts to liming when growing as pure sward or in mixture with other crops [12],[13]. The efficiency of N fertilization to both grasses DM yield depends on many ecological factors [14],[15].
To avoid competition with conventional food plants, energy crops could be cultivated in less favoured soils for farming. It is important to select the energy plant species which are undemanding to local soil and weather conditions [16],[17]. Out of large variability of soils in Western Lithuania, naturally acid *Albeluvisols* and

Fluvisols are prevailing there [18]. Since the cultivation of many traditional agricultural crops in such the soils is often unprofitable, due to increase of biomass demand, a significant part of infertile soils could be designated for some energy crops growing. Research aim – to evaluate the dependence of seven different perennial energy crops productivity (biomass and energy output) on different levels of liming and nitrogen fertilization.

MATERIALS AND METHODS

The trials with perennial energy plants were conducted in Vėžaičiai branch of the Lithuanian Research Centre for Agriculture and Forestry (55º43′ N, 21º27′ E). The soil of the experimental site is naturally acid moraine loamy (*Bathygleyic Dystric Glossic Retisol*). The soil characteristics of the experimental site are follows: pH_{KCl} – 4.25-4.85, mobile P_2O_5 – 35-120 mg kg^{-1}, mobile K_2O – 140-209 mg kg^{-1}, hydrolytic acidity – 21.9-62.1 cmol kg^{-1}, mobile Al – 10.7-50.9 mg kg^{-1}.

The whole experiment was relatively divided into three groups: short rotation forest plants: (common osier (*Salix viminalis* L.) and black poplar (*Populus nigra* L.), non-traditional plants: (common mugwort (*Artemisia vulgaris* L.), cup plant (*Silphium perfoliatum* L.) and virginia mallow (*Sida hermaphrodita* Rusby), perennial grasses: cocksfoot grass (*Dactylis glomerata* L.) and reed canary grass (*Phalaris arundinacea* L.). The experiment with all seven plants was laid out in a two factorial design.

1st factor – lime material (not limed (natural pH), limed by 3.0 t ha^{-1} $CaCO_3$, (to withdraw the effect of toxic aluminium), limed by 6.0 t ha^{-1} $CaCO_3$), 2nd factor – nitrogen rates (0 (not fertilized), 60 and 120 kg ha^{-1}). The entire experimental plot was divided into three strips differing by lime material application (or by different pH levels). All nitrogen treatments were randomly allocated in all three pH strips with three replications.

The liming was performed (except the first pH strip) in 2008, by applying Opokos lime material just before the establishing of the experiments. Each year, N fertilization of 60 kg ha^{-1} rate were spread in April just at the beginning of vegetation. An additional 60 kg ha^{-1} N rate (for the 3rd treatment) was applied in July. In turn, phosphorus and potassium fertilizers were applied each year at the beginning of vegetation at 60 kg ha^{-1} P_2O_5 and 60 kg ha^{-1} K_2O rates.

Common osier and black poplar were planted by cuttings in 2008 and were once harvested in autumn of 2012. Non-traditional plants: common mugwort and cup plant were planted by seedlings in 2008, and virginia mallow – in 2009. The biomass of all the three plants has been harvested each year at the end of vegetation, which felled at the end of September. Cocksfoot and reed canary grass were seeded in 2009. The grass yield was harvested each year per two cuts – at full maturity stage (1st cut) and the aftermath (2nd cut).

The estimated calorific value for common mugwort was 18.20 MJ kg^{-1}, for cup plant – 16.50 MJ kg^{-1}, for virginia mallow – 16.90 MJ kg^{-1}, for cocksfoot – 17.70 MJ kg^{-1} and reed canary grass – 17.47 MJ kg^{-1}. Biomass calorific value was measured at Klaipėda University's Maritime Institute Laboratory. The energy output (energy potential) (GJ ha^{-1}) from 1 ha was calculated by multiplying dry mass (DM) yield by calorific value.

The significance of studied parameters was analyzed by using analysis of variance (ANOVA), by choosing LSD_{05} to assess the significance [19].

RESULTS AND DISCUSSION

Dry matter (DM) yield.

The data of two short rotation forest plants – common osier and black poplar are presented in table 1. In average per 1 growing season, common osier accumulated 19.30 t ha^{-1} DM, on average (or 77.47% higher than the average poplar yield). There was no significant effect of liming to common osier yield. However, the liming (3.0 t ha^{-1} $CaCO_3$) positively influenced black poplar DM increment (DM yield increased by 19.86%). In compare with control treatment (0 kg ha^{-1} N), the application of 60 kg ha^{-1} N significantly increased osier and black poplar DM yield – by 29.09 and 45.53%, respectively. The doubling of N rate (up to 120 kg ha^{-1}) had a negligible effect to both crops DM yield increment.

As it is stated by other scientific sources, poplars are more demanding to soil conditions than many osier species. According the other personal observations during the experimental period, the establishment of poplar's stand is more complicated due to its low rooting of cuttings. Both crops biomass is being used for solid fuel, and rarely – for biogas production.

Table 1

The influence of liming and N fertilization on mean values of common osier and black poplar DM yield (t ha^{-1})

Factor	Common osier t/ha	Black poplar
Liming rate		
Not limed	19.47	9.81
Limed at 3.0 t ha^{-1}	19.34	11.98
Limed at 6.0 t ha^{-1}	19.09	11.75
N rate		
0 kg ha^{-1} N	16.33	8.28
60 kg ha^{-1} N	20.49	11.38
120 kg ha^{-1} N	21.08	12.05
In average per 1 season	19.30	10.88
LSD_{05} (for both factors)	*3.94*	*1.81*

According the results presented in table 2, the average annual common mugwort DM yield was 13.34 t ha^{-1}, which was notably lower than the other two species. Contrarily, cup plant distinguished by its high biomass productivity in all experimental years – 11.12 t ha^{-1}, on average. The effect of liming had a negligible effect to common mugwort DM yield. Since different *Artemisia* species could tolerate wide range of soil acidity, the increase of soil pH had no sufficient effect on biomass increment. However, the application of 6.0 t ha^{-1} $CaCO_3$ significantly increased cup plant and virginia mallow DM yield up to 12.43 t ha^{-1} (by 27.33%) and 6.65 t ha^{-1} (by 47.45%), respectively. The application of 120 kg ha^{-1} N fertilization increased common mugwort productivity by 52.46%, cup plant – by 27.95%, virginia mallow – by 97.92%.

Table 2

The influence of liming and N fertilization on mean values of common mugwort, cup plant and virginia mallow DM yield (t ha^{-1})

Factor	Common mugwort	Cup plant	Virginia mallow
Liming rate			
Not limed	3.50	9.87	4.51
Limed at 3.0 t ha^{-1}	3.33	11.05	5.75
Limed at 6.0 t ha^{-1}	3.71	12.43	6.65
N rate			
0 kg ha^{-1} N	2.84	9.73	3.84
60 kg ha^{-1} N	3.37	11.17	5.48
120 kg ha^{-1} N	4.33	12.45	7.60
In average per 1 season	3.51	11.12	5.64
LSD_{05} (for both factors)	*0.31*	*0.72*	*0.44*

Our trials revealed that despite high adaptability, common mugwort accumulated low amount of DM per all trail's years. It seems, that cup plant has the best prospects as energy crop than other species. Virginia mallow is more demanding for better soil conditions (especially for soil pH) than other two non-traditional crops.

By observing 2 different perennial grasses: cocksfoot and reed canary grass, the latter had the superiority by producing higher biomass yield (including 1st and 2nd cuts) in all experimental years (table 3). The average reed canary grass yield (8.59 t ha^{-1}) was by 41.28% higher than that of cocksfoot. 6.0 t ha^{-1} liming rate significantly increased cocksfoot DM yield (by 34.3%) and had no effect on reed canary grass yield.

The highly significant was the effect of N fertilization. The use of 120 kg ha^{-1} N rate increased cocksfoot and reed canary grass DM yield by 220% and 243%, respectively.

Table 3

The influence of liming and N fertilization on mean values of cocksfoot and reed canary grass DM (including I and II cuts) yield (t ha^{-1})

Factor	Cocksfoot	Reed canary grass
Liming rate		
Not limed	5.51	8.50
Limed at 3.0 t ha^{-1}	5.33	8.76
Limed at 6.0 t ha^{-1}	7.40	8.52
N rate		
0 kg ha^{-1} N	3.80	5.20
60 kg ha^{-1} N	6.08	7.96
120 kg ha^{-1} N	8.36	12.62
In average per 1 season	6.08	8.59
LSD_{05} (for both factors)	*0.34*	*0.37*

The data of these experiments shows that the most effective for perennial grasses is the application of high N rate in split doses (60+60 kg ha^{-1}) twice per vegetation. It is worth to note that to gain the highest perennial grasses DM yield, the harvesting of both crops was performed at full maturity stage.

***Energy output*.**
The results of energy output (energy accumulated in above-ground biomass) are presented in table 4. In average per 1 growing season, common osier energy output totalled 343-490 GJ ha^{-1}, which was by 55-109% higher than that of black poplar. The effect of liming had a minor effect on energy output of both crops. In turn, the application of 120 kg ha^{-1} N rate positively influenced the accumulation of energy under all liming levels.

Table 4

The energy output of different energy crops as affected by liming and N fertilization, GJ ha^{-1}

Treatments	Energy output, GJ ha^{-1}						
	Common osier	Black poplar	Common mugwort	Cup plant	Virginia mallow	Cocks-foot	Reed canary grass
Control	343	164	54.7	168	45.2	59.1	84.3
120 kg ha^{-1} N	488	292	82.2	238	97.4	139.5	218.5
3.0 t ha^{-1} $CaCO_3$	397	225	48.0	200	69.9	51.3	96.6
3.0 t ha^{-1} $CaCO_3$ + 120 kg ha^{-1} N	490	316	74.2	217	133.1	139.6	214.8
6.0 t ha^{-1} $CaCO_3$	409	207	52.2	227	79.4	91.6	91.6
6.0 t ha^{-1} $CaCO_3$ + 120 kg ha^{-1} N	448	261	80.3	274	155.1	164.8	228.0

Although common mugwort relative biomass energy value was high (18.2 MJ kg^{-1}), due to low DM yield, the energy potential was also lower than that of cup plant or virginia mallow. The effect of liming was relatively low. The use of 120 kg ha^{-1} N rate significantly increased the energy potential irrespective of soil pH level. In-between non-traditional crops, cup plant accumulated substantially higher amount of energy. The use of 6.0 t ha^{-1} and 120 kg ha^{-1} N rate had a significant impact to the increment of cup plant energy output. Virginia mallow energy potential was highly different among the treatments. In compare with control treatment (without liming), the application of 6.0 t ha^{-1} increased energy potential from 36.65 to 75.66%; also, the use of 120 kg ha^{-1} N rate increased energy potential approximately 2 times.
N fertilization apparently increased the energy output from cocksfoot (from 236 to 272%) and reed canary grass sward (from 249 to 259%). Contrarily, liming material had a minor effect on energy accumulation (especially for reed canary grass).

As it was already mentioned, the biomass of grassy crops was harvested at the moment of maximum energy accumulation in stems. It is likely that cup plant stems could be successfully utilized in biogas production. In that case, it is recommended to harvest the first yield not later than at flowering stage (at 2nd half of June). As for virginia mallow, its biomass could be better used for solid biofuel (briquettes, pellets) production.

As for both perennial grasses, the biomass harvested at full maturity stage is suitable for solid biofuel production, only. The 2nd cut grass is more suitable for biogas purposes, since the weather conditions are less favourable for grass sward drying at the end September; altogether, the C: N ratio is more suitable for biogas production.

CONCLUSIONS

According the data of four experimental years, the highest was common osier DM yield (19.30 t ha^{-1}, average annual). Cup plant DM yield (11.23 t ha^{-1}) was substantially higher than the average yield of other tall grassy plants. Among perennial grasses, the most productive was reed canary grass – the average yield was 8.59 t ha^{-1} (including 1st and 2nd cuts).

Both investigated factors - liming and nitrogen significantly increased black poplar, cup plant, Virginia mallow and cocksfoot DM yield and energy output from 1 ha. The productivity of common osier, common mugwort and reed canary grass was essentially determined by N application and much lesser extent – by liming.

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INCREASING BIOMASS FOR BIOENERGY PRODUCTION ON MARGINAL LANDS BY RED CLOVER OVERSEEDING

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Abstract. *Biomass from marginal lands is a potential resource for bioenergy by biogas or combustion process. Low biomass hectare yield results to high harvesting costs which are one obstacle for utilizing this resource. Red clover overseeding was studied as a measure to increase biomass yield on nature management field in Jokioinen, Finland. The trial had three treatments: no overseeding as control treatment (A). Overseeding red clover (Trifolium pratense) cv. 'Bjursele' at a rate 6 kg ha^{-1}on May 7 (B), and after the grass harvest on July 16 in 2010 (C). Experimental direct sowing drill (produced by modifying Tume Nova Combi drill by installing Oyjord sowing rate unit and narrowing the working width to 1,5 m) was used. The drill had double-disc units at row width 12,5 cm. Sowing dept was from 5 to 10 mm. Soil at the experiment was loam clay. The sward was established in 2005 as an experiment with four grass species. Overseeding was carried out diagonally towards the grass species. Two 1,5 m wide overseeding lines formed one plot. Plot size was 4,5 m^2 with three replicates. Results are presented as all grass species pooled. Treatment B increased the dry matter yield substantially in 2011 from 2176±773 to 5529±985 kg ha^{-1} and in 2012 from 1716±1014 to 6190±701 kg DM ha^{-1} compared to control treatment A. However, treatment C yielded only 2080±934 and 2152±938 kg DM ha^{-1} in 2011 and 2012, respectively. Percentage of red clover in harvested fresh biomass was high in treatment B, 78±7 and 81±11 percent in 2011 and 2012 compared to 2±4 and 9±14 percent in the control treatment A. However, the percentage of red clover remained low in treatment C: 3±3 and 19±17 in 2011 and 2012, respectively. Weather conditions effected strongly establishment of red clover. In May precipitation (73 mm) came to suitable time and establishment of red clover was successful. July (precipitation 42 mm) and August (54 mm) were dry and very warm in 2010, and establishment of red clover was very weak. Red clover overseeding increased phosphorus removal by harvest. Phosphorous removal was 11-12 kg P ha^{-1} in treatment B compared to 4-5 kg P ha^{-1} in control treatment A. Overseeding old nature management field by red clover can increase biomass production and removal of phosphorous from soil. It is important to harvest the biomass in order to reduce risk for leaching of nutrients from the vegetation during winter and spring.*

Key words: *bioenergy, biomass, red clover, overseeding, phosphorous uptake.*

ORGANIC FARMERS WITH INNOVATIVE APPROACHES TO THE FOOD MARKETS: CASE STUDIES FROM HEDMARK COUNTY, NORWAY

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Abstract. *The Norwegian government has set a target that 15% of the agricultural production in Norway should be organic by year 2020. It seems hard to reach this target for several reasons, one of them being limited willingness among the consumers to pay a significantly higher price for organic food compared to conventional food. A study was therefore conducted in order to find out to what extent producers achieve a price premium for organic food as compared to conventional food, how they adapt when they don't experience the expected price premium, whether direct marketing (e.g. farmers' markets, subscription and farm outlets) give a higher price premium than large scale marketing facilities, and what ideas farmers have for improved marketing to achieve a higher producer price on organic food. These objectives were addressed by in-depth interviews of seven organic farmers who all had experience from both direct sales to consumers and sales through large-scale food marketing companies. All interviews were made face-to-face at the respondents' own farms. It turned out that the price differences between organically produced food and conventional food varied from about zero to a factor of three, depending on the types of products and the way they were marketed. In many cases, the impression of the farmers was that consumers appreciated local, short-travelled, high quality food based on production systems with good animal welfare more than they valued the fact that the production was organic. Most of the farmers had made changes in their production patterns over time, but decisions to make changes were in most cases guided by other factors than low price premiums for organic products. Generally, the farmers experienced higher prices through direct sales to consumers than through intermediaries, but some farmers found direct sales too time consuming. Farmers thought that marketing of organic food could be improved by increasing the selection of organic foods and giving them a better exposure in the supermarkets, providing more information on the origin of the products and how it is produced, and imposing stricter rules for food to be certified as organic.*

Key words: *case studies, in-depth interviews, food markets, marketing, organic agriculture.*

PLANT NUTRIENT RECYCLING FROM WASTE PRODUCTS OF BIOENERGY PRODUCTION

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Abstract. *The necessity to increase the share of renewable energy requires expanding the use of green energy. In Latvia one of the most suitable sources for bioenergy generation could be biomass obtained from perennial grasses. Grasses are modest in terms of soil conditions and do rather well on marginal lands that are unfavourable for food production and are currently unused [1]. The cultivation of grasses on degraded or exhausted agricultural soils can help in restoring the soil's organic carbon and improve its physical properties [2]. In the process of biomass combustion or its fermentation for biogas production waste products such as ash or digestate are obtained. This material is rich in plant nutrients and can be used for soil improvement and/or fertilisation of crops. In order to study the effectiveness of applying these waste products on reed canary grass (Phalaris arundinacea L.) and festulolium (×Festulolium pabulare) experimental trials were arranged in the central part of Latvia (56°42' N and 25°08' E) on Endoluvic Epistagnic Phaeozem (Loamic)/Stagnic Retisol (Cutanic, Drainic, Loamic) [3], fine sandy loam in 2012. In all fertiliser treatments: (wood ash – WA, digestate once per season – D1; digestate twice per season – D2 and mineral fertilisers – MF) the same amount of plant nutrients: N (100), P_2O_5 (80), K_2O (160) was provided annually. The missing quantities of elements in ash and digestate plots were compensated by mineral fertilisers. Fertilised treatments were compared with the control (C – not fertilised). For accounting of grass biomass two harvest regimes were used – two-cut per season and one-cut per season (late in autumn at the grass senescence) harvest systems. The chemical composition of grass biomass: ash content; total C, N, P, K, S; Ca and Mg were determined.*

Two-year trial results suggested that the productivity of perennial grass biomass was dependent on the type of fertilisers applied, grass species and harvest regime. The dry matter yields (DMY) in general were higher for reed canary grass (RCG): in two-cut harvest regime – the obtained DMY ranged from 4.08 to 8.57 t ha^{-1} in the 1st year of use and from 4.01 to 8.62 t ha^{-1} in the 2nd year of use. For festulolium in two-cut harvest regime DMY were 2.61-5.02 t ha^{-1} in the 1st year of use and 1.11-3.78 t ha^{-1} in 2nd year of use. Both species produced larger yields in one-cut harvest regime: 6.36 to 10.0 t ha^{-1} in 1st year of use and 4.74-7.11 t ha^{-1} in 2nd year of use for RCG; 3.54-7.73 t ha^{-1} in 1st year of use and 1.19-5.66 t ha^{-1} in 2nd year of use for festulolium. The largest DMY on average in two years for both grass species were obtained in fertilisation treatments using wood ash (WA) and mineral fertilisers (MF). The use of digestate provided a significant increase of DMY in comparison with the control, although it did not provide an equivalent yield increase as it was in WA and MF treatments due to partial emission of nitrogen in the form of ammonium. The chemical composition of grass biomass was mostly influenced by grass species and harvest regime: lower ash content (4.0- 5.4%) and hence more appropriate raw material for combustion can be obtained by mowing RCG once per season late in the autumn. RCG provided biomass with a relatively lower K (14.7-16.6 g kg^{-1}) and higher C (498.3-510.6 g kg^{-1}) content on average using the two cutting harvest regime.

Key words: *fertilisation, festulolium, reed canary grass, yield, biomass quality.*

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CURRENT STRUCTURE OF LAND HOLDINGS AND IMPORTANCE OF SMALL FARMS: EVIDENCES FROM PAKISTAN

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Abstract. *In agrarian economies like Pakistan, agriculture structure especially, pattern of ownership of land and size distribution are crucial indicator and principal form of wealth and political power. The present study represents an attempt to look in current structure of land holdings, land tenure, and land fragmentation by using Pakistan agriculture census report 2010. Opportunities and challenges faced by small farms in Pakistan are also discussed. Despite two land reforms (1959, 1972), to reform the feudal agrarian structure of the country, agricultural lands are highly skewed in favor of large farms. This dominancy of large farms in owning means of production leads to severe inequalities in the distribution of wealth and income which is major obstacle in provision of basic need to large proportion of population. Tenancy, a problem in the past because poor tenants were handicapped in accessing different institutes and services, is solved somehow. Despite different consolidation programs in the past, the fragmentation issue is there, 34 percent of total farm area is fragmented in Pakistan. Fragments are barrier in investment in farm development projects on farm level. A majority of farms (58%) in Pakistan are small farms, so for the prosperity of country, well-being of small farms is very important. Due to diversification of agriculture from cash crop to high value commodities, and concepts like tunnel farming, organic agriculture, horticulture and livestock, small farms tend to offer some opportunities. On the other hand, natural disasters, pest attacks, access to financial markets, unfavorable macro-economic policies are threatening the prosperity of small farms.*

Key words: *land holdings, agriculture census report, small farms, high value commodities, Pakistan.*

INDUSTRIAL HEMP (*CANNABIS SATIVA* L.) PRODUCTIVITY AND RISK ASSESSMENT IN HEMP PRODUCTION

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Abstract. *The sector of hemp growing and processing is subjected to significant changes through the past decades, historically hemp growing was widespread and in Latvia hemp was broadly used in everyday life – in the local cuisine, for feeding animals and also as a building and textile material. It had lost its popularity but following the global tendencies in agriculture, growing and processing of hemp (cannabis sativa L.) is slowly regaining its positions mainly due to the versatile possibilities of using hemp. Though the total number of hemp growers is significantly smaller nowadays as it has been historically, the use of hemp is expanding and during recent years several enterprises have introduced new products that includes using hemp in food production, production of ecological construction materials, paper, production of textiles, biodegradable plastics and as mentioned, renewable energy production. Agriculture, including hemp production and processing, is one of the industries subject to risks due to changing weather conditions, diseases and pests and volatile market prices on inputs and products produced. This article aims to reflect the results of the risk evaluation in hemp production and processing, for the evaluation purposes the hemp production is divided in five stages – preparation of soil and sowing of hemp; growing of hemp; hemp harvesting; hemp processing; and realisation of the produced output. The evaluation of risks was made within a system of 18 risks, divided in 6 main groups – agro-meteorological; technological and production; personnel; environment; legislative; economical and market risks. The results reviles, that the highest risk level in the entire hemp production and processing process was specific to the group of personnel risks, whereas the lowest – to the group of environmental risks. However, some risks were assessed as the highest for the group of technological and production risks, for instance, the unavailability of machinery during hemp harvesting and processing.*

Key words: *risk management, hemp production, hemp processing, risk evaluation.*

INTRODUCTION

Growing of hemp in Europe has a history of several hundred years. And it has been an important crop in many European countries as UK, France, the Netherlands, Germany, Spain and Italy. Most important applications for the strong fibre were canvas for sails, sacks, canvas water hoses, fabrics and ropes [1].

Nowadays hemp is a niche crop, cultivated on 10,000 to 15,000 ha in the European Union, but the largest hemp producing countries in the world are China, North Korea, and Canada. In China and North Korea, hemp is annually sown within approximately 80 000 hectares, in Canada − about 10 000 hectares. Among the European Union countries, most hemp is grown in France, Germany, the United Kingdom, and the Netherlands. Overall, in Europe 22,000 to 24,000 tons of hemp fibre and 44,000 to 48,000 tons of hemp sheaves are produced annually [2],[3].

Because of its unique properties, particularly its environmental benefits and the high yield of natural technical fibres, hemp is a valuable crop for the bio-based economy. According to the data of the European Industrial Hemp Association, the dynamics of hemp production has been unsteady − it has increased significantly in 2009, but then decreased in 2011 and now again a tendency to increase the area in which the hemp is grown can be observed [1].

As the hemp growing in Latvia increases, there have been several research projects in Latvia University of Agriculture and Riga Technical University funded by EU structural funds researching the properties of the hemp fibre and its use for building materials [4],[5] and heating thus highlighting the multifunctionality of the crop and the various use of it. Also this paper is based on the empirical data obtained within a nationally funded project ,,The elaboration of growing and processing technologies for the use of Industrial hemp (*Cannabis sativa*) in development of products with a high added value'' which aimed to investigate the productivity of several hemp varieties and the risks involved in the production and processing of hemp.

MATERIALS AND METHODS

Field trials were carried out in 2012-2014, in Research and Study farm 'Pēterlauki' that is supervised by the Latvia University of Agriculture. 10 industrial hemp (*Cannabis sativa* L.) cultivars – 'Bialobrzeskie', 'Futura 75', 'Fedora 17', 'Santhica 27', 'Beniko', 'Ferimon', 'Epsilon 68', 'Tygra', 'Wojko' and 'Uso 31' were sown in the sod calcareous soil (pHKCl 6.7, containing available P 52 mg kg $^{-1}$, K 128 mg kg $^{-1}$, organic matter content in the soil from 21 to 25g kg^{-1}). Total seeding rate comprised 50 kg ha^{-1}. The plots were fertilised as follows: N-120, P2O5- 90, K2O- 150 kg ha^{-1}. Hemp was sown by using Wintersteiger plot sowing machine in the middle of May, in 10 m^2 plots, triplicate. Hemp was harvested by a small mower 'MF-70' when first matured seeds appeared. Biometrical indices of the hemp seedlings, height and stem diameter in the middle thereof at harvesting time, amount of green and dry over ground mass, and fibre content were evaluated.

Besides the growing of hemp in the trial fields a classification of risks was performed by analysing risk management researches in agriculture and in the field of production of renewable energy [6]-[9]. To obtain the preliminary risk evaluation results, 3 experts were questioned all of them were involved in hemp production or research of hemp production. These experts determined the probability of occurrence of each risk and the potential severity of losses from the occurrence of it. Based on the results, a risk level was calculated for each risk assessed by the experts; from it, in its turn, the average risk level was calculated for all the three experts' assessments, as well as the average risk group level for the 6 basic groups of risks and for each phase of the production and processing process.

RESEARCH RESULTS AND DISCUSSION

The results obtained from the field trials indicate that yield of hemp dry matter acquired within the field trials under agro-climatic conditions of Latvia on average comprised 15.06 (13.32-17.78 t ha^{-1}, depending on the variety. Cultivation year and selected variety notably affected hemp biomass yield (Table 1). In 2012, notably higher yield of dry biomass was produced by cultivars 'Futura 75' (21.33 t ha^{-1}) and 'Tygra' (20.87 t ha^{-1}), while the lowest – by cultivar 'Bialobrzeskie' (11.95 t ha^{-1}. Average significantly higher yield of dry biomass was obtained from cultivars 'Futura 75' (17.76 t ha^{-1}), 'Tygra' (16.31. t ha^{-1}), 'Wojko' (15.51 t ha^{-1}) and 'Epsilon 68' (15.28.26 t ha^{-1}), whereas the lowest – from cultivar 'Bialobrzeskie' and 'Uso 31' (13.53 t ha^{-1}). Statistical assessment showed that meteorological conditions present during the growing season influence total volume of the dry biomass yielded.

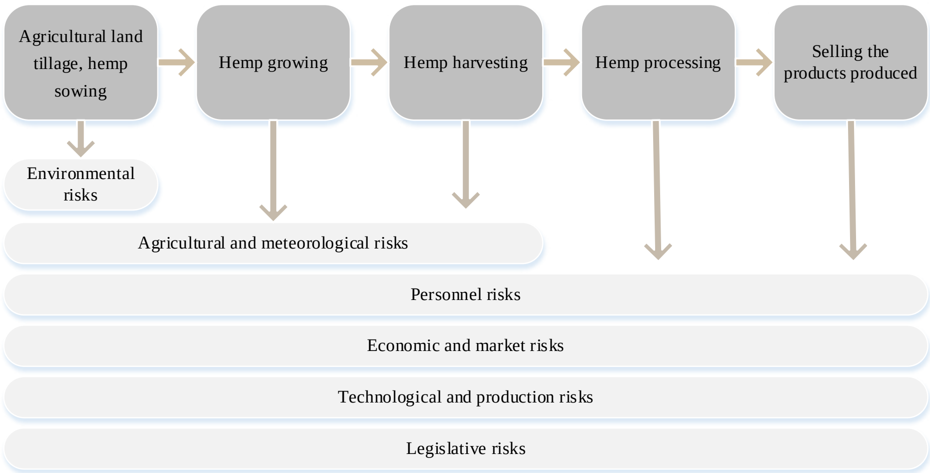
Table 1

Biomass yield from different industrial hemp varieties, 2012-2014

Hemp variety	Dry biomass, t ha^{-1}			
	2012	**2013**	**2014**	**Average**
Bialobrzeskie	11.95	12,91	15.56	**13.47**
Futura 75	21.33	17.14	14.81	**17.76**
Fedora 17	18.23	13.32	12.78	**14.78**
Santhica 27	17.39	11.57	13.47	**14.14**
Beniko	19.27	13.30	11.96	**14.84**
Ferimon	18.59	13.09	12.93	**14.87**
Epsilon 68	12.89	18.47	14.47	**15.28**
Tygra	20.87	14.66	13.40	**16.31**
Wojko	19.91	14.83	11.79	**15.51**
Uso 31	17.38	11,40	11.98	**13,59**
Average	**17.78**	**14.07**	**13.32**	**15.06**
LDS0.05 variety		3.15		
LDS0.05 year		1.92		
LDS0.05 interaction between variety and year		4.03		

Source: made by the authors

The influence of the growing conditions was also included in the risk assessment for the hemp production and processing performed by the experts. In general, agriculture, including hemp production and processing, is one of the industries subject to risks due to changing weather conditions, sicknesses and pests and volatile market prices on inputs and products produced. However, the use of risk assessment methodologies in agriculture is not widespread, after analysing the term risk in scientific literature [10]-[15] and the principles in risk definition set by German sociologist Ortwin Renn [16], risks within the present research were defined as follows: *risk is a combination of the probability of occurrence of an event and the severity level of negative effects caused by it*. This definition includes two components: probability of occurrence of a risk and severity of losses from the occurrence of the risk.



Source: made by the authors

Figure 1. **Classification of risks for assessing the risks in hemp production and processing**

Table 2

Characteristics of the risks in hemp production and processing and their distribution by group of risks

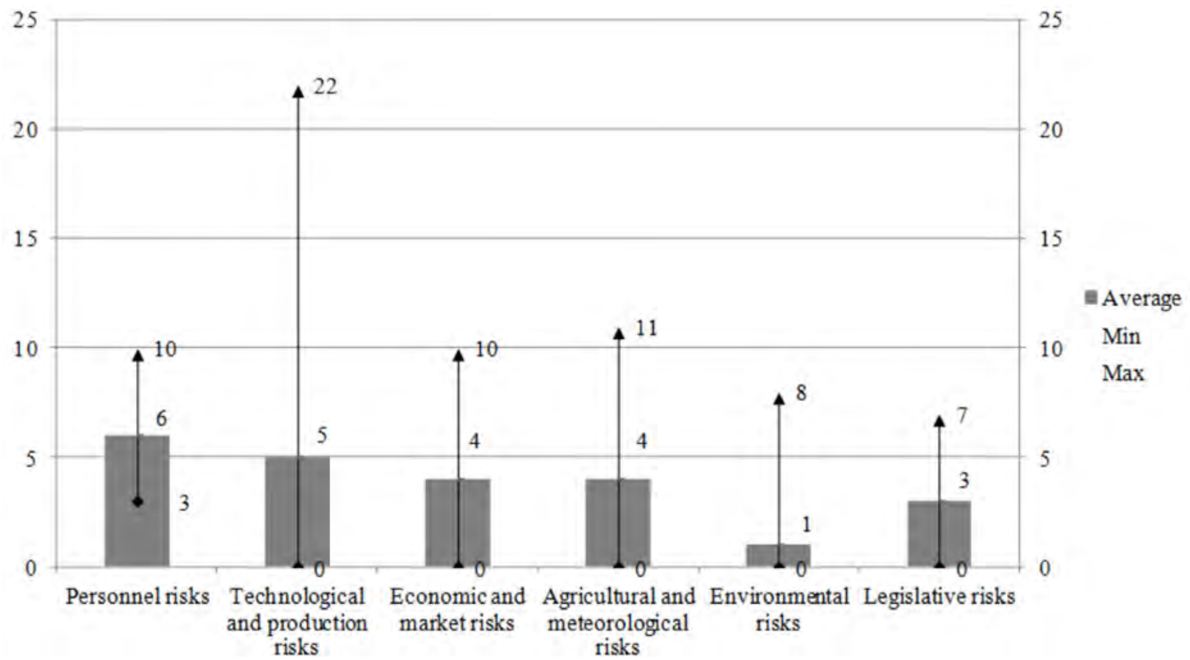
Characteristics of risks	Group of risks
Low qualification of personnel and the lack of their responsibility	Personnel risks
Violations of occupational safety rules	
Low quality of seed	Technological and production risks
Unavailability of machinery	
Machinery operational problems	
Low quality of agricultural and technological operations	
Delayed deliveries of spare parts for equipment and delayed maintenance services	
Changes in sale prices on products	Economic and market risks
Changes in purchase prices on inputs (seed, plant protection chemicals, fertilisers, etc.)	
Changes in other fixed and variable costs	
Effects of meteorological conditions	Agricultural and meteorological risks
Effects of pests and birds	
Inadequacy of agricultural land for growing hemp	
Environmental risks when fertilising fields	Environmental risks
Environmental risks when processing hemp	
Limitations of receiving direct payments	Legislative risks
Changes in the tax policy	
Changes in the quality and safety standards for the products produced	

Source: made by the authors

Given the above-mentioned, a risk assessment system was developed to assess risks in hemp production and processing; the risks in it were classified into 6 basic groups: technological and production, personnel, environmental, economic and market, and agricultural and meteorological risks. Within the basic groups of risks, a detailed classification of the specific risks affecting the production process was developed based on the analysis of specific scientific literature [17]-[20].

The process of hemp production and processing is divided into five phases: agricultural land tillage and hemp sowing; hemp growing, hemp harvesting, hemp processing and selling of the production (Fig. 1). To assess the risks, the mentioned six groups of risks were divided into 18 particular factors (Table 2). A specific effect area and a risk level were determined for each of these factors.

To assess the risks, the mentioned six groups of risks were divided into 18 particular factors. For each of these factors, a specific effect area and a risk level were determined using a scale of 1 to 25, where 1-3 points meant acceptable risks, 4-9: moderate risks, 10-19: significant risks and 20-25: extreme risks [21].



Source: made by the authors

Figure 2. **Dispersion of the significance of risks for the groups of risks for all the phases of hemp production and processing**

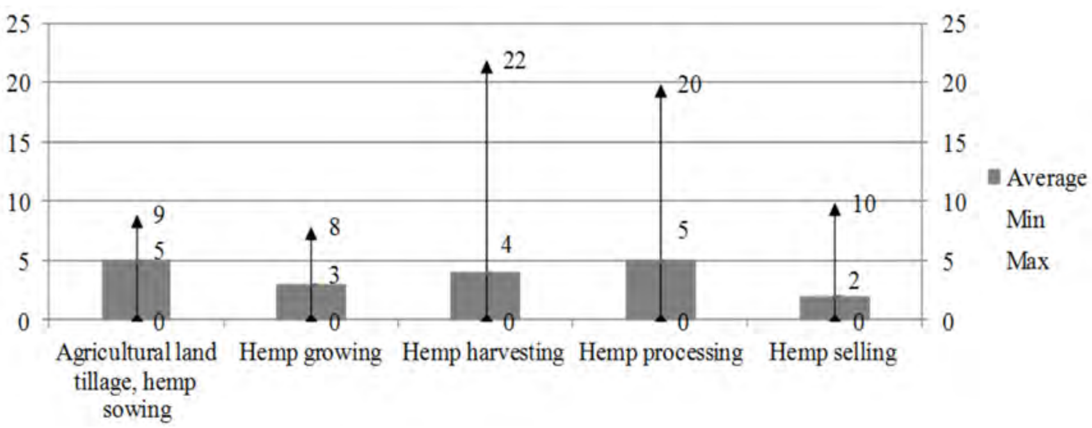


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Figure 3. Dispersion of the significance of risks for the phases of hemp production and processing

The results obtained from the experts' risk assessment showed (Fig. 2) that, on average, the highest risk level in the entire hemp production and processing process was specific to the group of personnel risks (6), whereas the lowest – to the group of environmental risks (1). The group of personnel risks was the only group of risks that was homogenously assessed by the experts as moderately significant for all the phases of hemp production and processing. However, some risks were assessed as the highest for the group of technological and production risks, for instance, the unavailability of machinery during hemp harvesting and processing.

After analysing the results for each phase of hemp production and processing (Fig. 3), one can find that, on average, the risk effects were assessed as the highest for agricultural land tillage and hemp sowing, while some very significant risks were specific to hemp harvesting and processing, at 22 and 20 points, respectively, and, as mentioned before, this was the risk of unavailability of machinery.

After analysing individual risks for each phase of hemp production and processing, one can find that the experts' assessments for agricultural land tillage and hemp sowing were quite different – on average, the most significant were the risk of changes in purchase prices on inputs (seed, plant protection chemicals, fertilisers, etc.) (9), the risk of low quality of seed (7) and the risk of changes in the tax policy (7). For the phase of hemp growing, the most significant were agricultural and meteorological risks, especially effects of pests and birds, with the maximum of 20, and the inadequacy of agricultural land for growing hemp; however, this phase does not involve several risks associated with hemp sowing and processing. For the phase of hemp harvesting, the risk of unavailability of machinery was extremely significant, 22 points; therefore, this was the most significant risk not only for a particular phase but for the entire risk assessment. The following risks, for the same phase, were also significant: effects of meteorological conditions, low quality of agricultural and technological operations and low qualification of personnel and the lack of their responsibility, while machinery operational problems were a moderately significant risk. For the phase of hemp processing, too, the most significant risks were unavailability of machinery (20) and machinery operational problems (11); two personnel risks, with 10 points, were also significant. As regards the phase of sales of products, the risk effects were comparatively lower; on average, significant risks were: changes in sale prices on products (10) and low qualification of personnel and the lack of their responsibility (7). On the whole, the lowest assessments were given to the groups of environmental and legislative risks – environmental risks quite insignificantly affect all phases, while legislative risks can affect several phases more; yet, since presently no changes are expected regarding legal provisions, standards or taxes, the effects of these risks are small.

This preliminary risk determination and assessment allowed to test the risk evaluation methodology and obtain the first results, and further, the research will focus on the differences in risk effects depending on the ways of using hemp. Since the present results show the distribution of significance of risks for hemp production and processing, but the experts, when doing their assessments, admitted that this was a quite complicated and time-consuming activity, the further research will omit insignificant risks and will focus only on those presently having moderately significant and significant effects.

CONCLUSIONS

The field trials show that the industrial hemp cultivars 'Bialobrzeskie', 'Futura 75', 'Fedora 17', 'Santhica 27', 'Beniko', 'Ferimon', 'Epsilon 68', 'Tygra', 'Wojko' and 'Uso 31' could be successfully grown in Latvia for biomass and fiber production. The highest biomass yield, during both trial years, was obtained from cultivar 'Futura 75'. According to the data we can conclude that the growing season and the selected industrial hemp variety had a significant ($p<0.05$) effect on hemp yield.

The obtained results from risk evaluation showed that, on average, the highest risk level in the entire hemp production and processing process was specific to the group of personnel risks, whereas the lowest – to the group of environmental risks. Indicating that the actions and the decisions made by the employees are the one that affect the hemp growing and processing process the most. However, some risks were assessed as the highest for the group of technological and production risks, for instance, the unavailability of machinery during hemp harvesting and processing.

The significance of risk groups and also individual risks differed among the risk groups, for example, for the phase of hemp growing, the most significant were agricultural and meteorological risks, especially effects of pests and birds, with the maximum of 20, and the inadequacy of agricultural land for growing hemp, but for the phase of hemp harvesting, the risk of unavailability of machinery was extremely significant, and reaching 22 points.

ACKNOWLEDGEMENTS

The article is based on the empirical data obtained within the project ,,The elaboration of growing and processing technologies for the use of Industrial hemp (*Cannabis sativa*) in development of products with a high added value'' no. 160413/S99

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EVALUATION THE EFFECT OF WETLAND ON RURAL INCOME AND AGROBIODIVERSITY (CASE STUDY: HOSHEYLAN WETLAND)

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Abstract. *Wetlands are one of the important areas to conserve and enhance biodiversity. Enhancement of agrobiodiversity around the wetlands can be done the important role in the rural people economically and socially. The present study was performed to investigate the effects of social-economic aspects on the agrobiodiversity. Several villages around the wetland were selected from west of Iran (Kermanshah province) and finally 119 questionnaires were completed using interview. At first step, number of family members was investigated and the mean is resulted 5.21 person that indicated to the being populated rural households. Results from regression test suggest us that there is an inverse relationship between number of family members and Shanon index (-0.01), namely the populated families have lowest variety. In the next step, relation between farmer income and crop diversity is measured using regression test and concluded a significant value (0.18*) from income and Shanon index. Generally, farmers with more income have very diverse crops. The reason of this result is that with increasing the income, part of the economic needs of farmers supplied then they prefer to cultivate various crops and in conclusion the agrobiodiversity will be increased. Finally, wetland with providing the suitable income resource for rural populations, play the important role in development of economic-social and ecologic aspects of the adjacent regions and also can provide agrobiodiversity and species conservation.*

Key words: *economic-social factors, biodiversity, income, family members.*

EUROPEAN AND LATVIAN ECO-CONSTRUCTION CONSUMER MARKET RESEARCH AND ECO-CONSTRUCTION FOCUSED BUSINESS POTENTIAL

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Abstract. *The research covers main aspects of the eco-construction principles, European and Latvian related legislative background. It represents few eco-construction habitat examples as an alternative for the conventional construction standards. In addition, the author of the research describes the core advantages of the "green" and/or "passive" houses from both economic and social perspectives. The aim of the research is to analyse the consumer market, values and potential behavior of the customers. The author is going to identify the target market of eco-construction products and to reveal the business initiation success and opportunities on the Latvian and Baltic real estate market. The results of the research will answer 2 main questions – "What is important for the consumers when buying, building house?" and "What are the eco-construction business perspectives in the current real estate market?"*

Key words: *eco-construction, eco-construction principles, eco-construction consumer market, Europe and Latvia, values.*

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INVESTMENTS IN AGRICULTURE RESEARCH IN LATVIA

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Abstract. *This research provides a review of recent trends on investment in agricultural research in Latvia including a description of the funding system for agriculture research, an assessment of the availability of data and an analysis of recent investment trends. The research results reflected in this paper were used to prepare a Review for Latvia – a study on investment in agricultural research for the project IMPRESA under the 7th Framework Programme. When analysing the data availability one may conclude that there is a lack of consistent, comparable and publicly available data on R&D expenditures regarding agriculture. Total R&D expenditure for Agricultural sciences in Latvia has increased from € 3 million in 2000 to € 13 million in 2011. In 2011 the share of agricultural expenditure in total GERD expenditure was 9%. The EU funding programs have facilitated the increase of R&D expenditure, involving not only government and higher education institutions but business enterprises as well. Comparing to the data for scientific institutions of all sectors, scientific institutions working in agriculture are less involved in the framework programmes and international projects and also receiving less income in the tenders from the state budget, but comparatively more funds are received from contracts with private sector.*

Key words: *agricultural research expenditures, public and private investments.*

INTRODUCTION

From 2011 to 2013 the growth of Latvian economy on average amounted to 4.7% annually, which puts Latvia among the fastest growing economies in the EU, although the Gross Domestic Product (GDP) per inhabitant in Latvia was 7 100 euro in 2013 [1] – it is 70% of the world's average and 30% of European Union member states' average [2]. In 2014 the economic growth rate slowed down, which was driven by trends in the external environment: slower growth within the EU as previously expected, and the complications of the economic relations with Russia. Still the Ministry of Economics of Latvia expects GDP growth rate in 2015 to reach 2% [3],[4]. The share of agricultural, hunting and forestry in the gross value added was 3.6% in 2013, the share of agri-food sector – 2.5% in 2012. The total gross value added in current prices by both agriculture and agri-food sectors increased since 2011 [5]. In 2012 there were 92.1 thousand agricultural holdings in Latvia; in 2013 the number of agricultural holdings decreased to 81.8 thousand. These are mainly small farms, on average the total land area per holding is 29.1 ha [5],[6]. Share of labor force in agriculture, forestry and fishing was 8.4% of total employed in national economy in 2013, but a 0.3% decrease in employment in 2015-2016 for this sector is forecasted. The industry's export growth has positively affected Latvia's agricultural and food product foreign trade balance, which still remains negative [7]. The Europe 2020 strategy sets a 3% of the GDP objective for R&D intensity [8] and in the Law of Scientific Activity of Latvia an annual increase of 0.15% from the GDP is set till the state funding for R&D reaches 1% from the GDP [9]. Despite, the fact that the funding of research in Latvia has increased significantly – from 18 million euro in 1995 to 147 million euro in 2012; the R&D expenditure as share of GDP in Latvia is still very low – 0.66% in 2012[1].

This research aims to evaluate recent trends on investment in agricultural research in Latvia, including description of the national agriculture research system, an assessment on the availability of data and an analysis of recent investment trends. Agricultural research covers all research on the promotion of agriculture, forestry, fisheries and foodstuff production. It includes: research on chemical fertilisers, biocides, biological pest control and the mechanisation of agriculture; research on the impact of agricultural and forestry activities on the environment and research in the field of developing food productivity and technology.

MATERIALS AND METHODS

This research is performed using monographic, analysis and synthesis also statistical analysis methods and the data collected by Central Statistical bureau of Latvia and Eurostat. The authors carried out interviews and consultations with the leading representatives of 3 institutions working in agriculture research and with the representative from the Ministry of Agriculture during January to February, 2015. The research results reflected in this paper were used to prepare a Review for Latvia – a study on investment in agricultural research for the project IMPRESA: The Impact of Research on EU Agriculture (a project under the 7th Framework Programme).

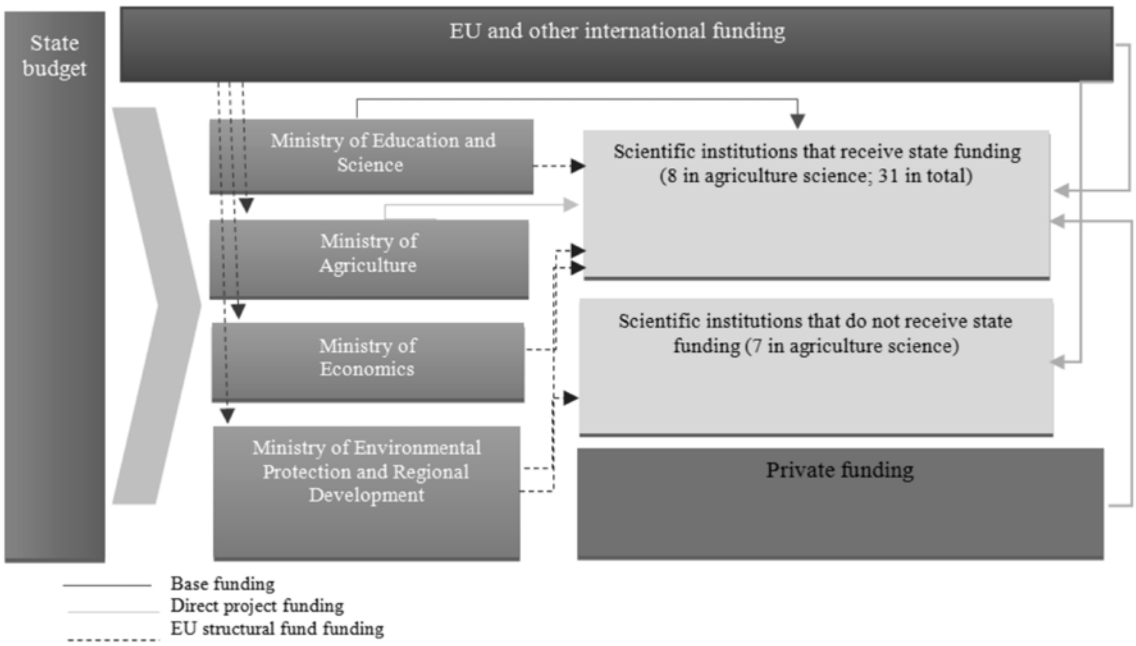
Data Availability on Agricultural Research Expenditures

Although the information on total R&D expenditure is available since 1993, detailed data regarding sectors are available since 1995, the data in agriculture both in public and private sector are fragmented and in many cases – unavailable. Total R&D expenditure for the classification by fields of science (FOS) for Agricultural sciences in Latvia is available from 2000 till 2011. There are no available data on R&D expenditure in private non-profit sector. The data on public sector expenditure for agriculture science are available for previous eight years, starting from 2006, what limits analysis of long-term tendencies and forecasting. The Business Enterprise R&D expenditure for the agricultural sector and the food processing sector showed trend breaks due to a change in the data collection methodology – therefore complete information according to the latest methodology is available only for 2010. When analysing the data availability one may conclude that there is a lack of consistent, comparable and publicly available data on R&D expenditures regarding agriculture.

RESULTS AND DISCUSSION

Overview of Latvian agricultural education and science system

Research and education in Latvia are provided both by public and private institutions. Secondary agricultural education is provided in 10 agricultural secondary schools and colleges [11]. But the higher education in BSc, MSc and PhD levels in agriculture, forestry and veterinary medicine can be obtained in the Latvia University of Agriculture. There are also two groups of research institutions – state and private institutions. In 2015 there are a total of 91 scientific institutions, from those 15 scientific institutions work with various topics of agriculture research, 8 of them are state funded and receive core public funding [12].



Source: made by the authors

Figure 1. **Distribution of funding in the agriculture science in Latvia**

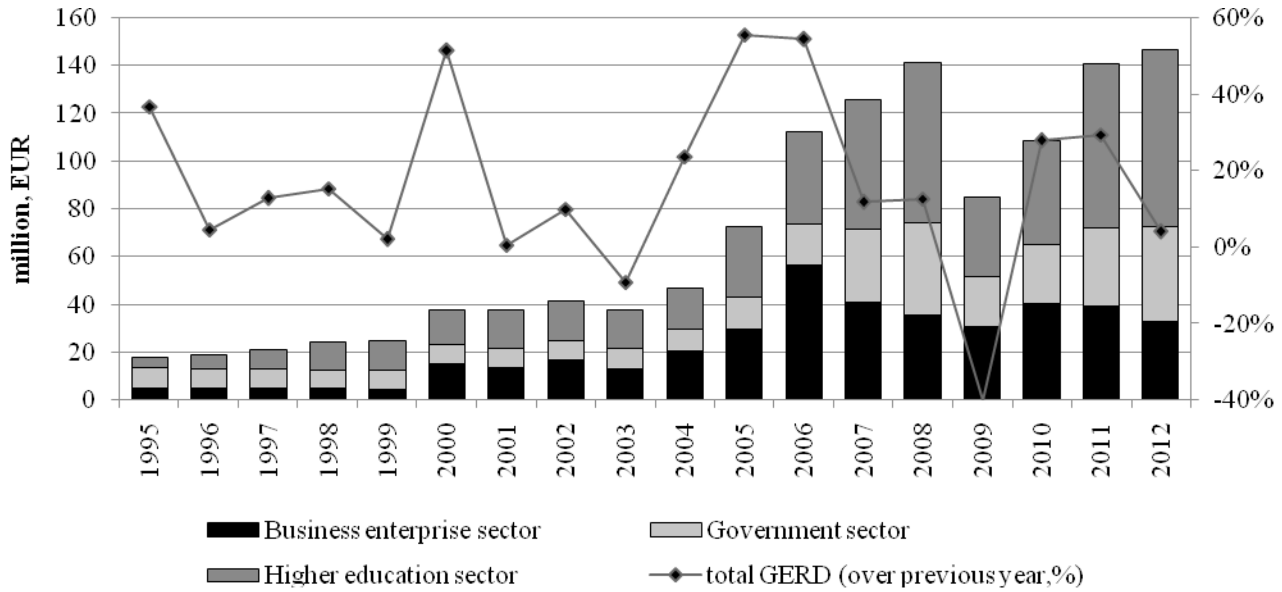
Research and education is highly dependent on the public sector, because it is funded by the state budget and the funding is allocated by the sectorial ministries. The overall research policy planning, evaluation and distribution of the core funding is done by the Latvia Ministry of Education and Science, but the research priorities in agriculture are set by the Latvia Ministry of Agriculture in accordance to the relevant topicalities of the sector in the EU.

There are three main funding sources for the scientific institutions (see Fig. 1) – 31 institutes receive core funding from the State budget. Apart from core funding, all scientific institutes can compete for the national grants and projects, including under the State Research Programme.

Recent trends regarding investment in agricultural research

The available data shows that the Gross domestic expenditure on Research and Development expenditure (GERD) in Latvia has increased significantly in 18 year period – from € 18 million in 1995 to € 147 million in 2012 (see Fig. 2). Despite such increase, the R&D expenditure as share of Gross Domestic Product (GDP) in Latvia is very low (0.66% in 2012) comparing with average share of R&D expenditures in the EU counties – 2.07% in 2012.The highest share was observed in 2006 – 0.7% of GDP, but then it dropped till 0.49% in 2009 as a result of economic recession.

When analysing the GERD tendencies over a time period, the clear impact of economic recession can be observed. Before accession to the EU in 2004, the increase of R&D expenditure over previous year was ~ 10%, excluding year 2000 when per-accession programs were opened. After 2004 till 2008 the annual increase was substantial – reaching 56% in 2005; followed by decrease in 2009 by 40%. The largest share of this expenditure mainly comes from the higher education sector (50% of the total GERD expenditure in 2012), since higher education establishments are most familiar with structural funding for science.



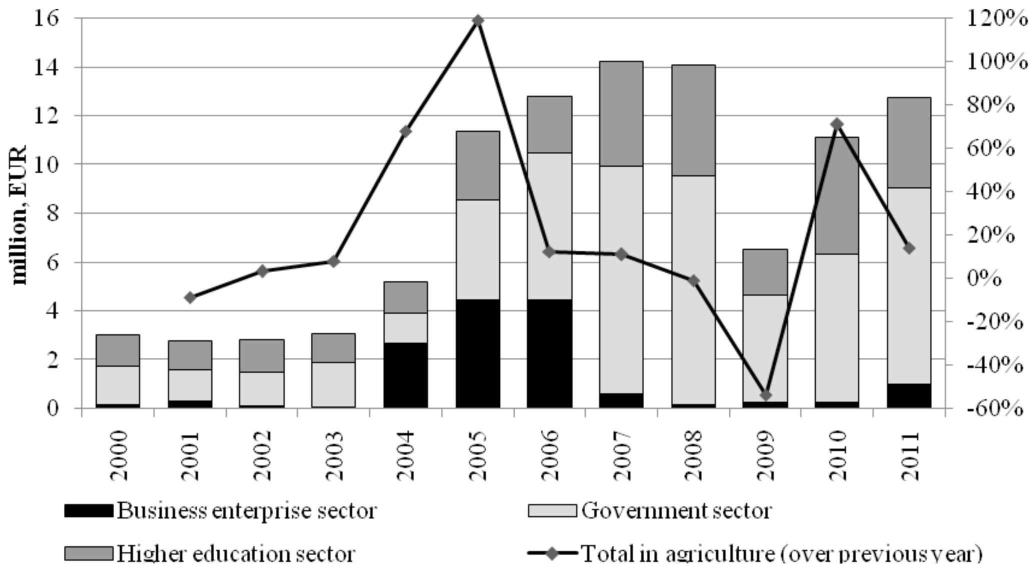
Source: [2]

Figure 2. **GERD for business enterprise, government and higher education sectors, 1995-2012**

Total R&D expenditure for the classification by FOS for Agricultural sciences in Latvia has varied due to macro-economic issues – the accession to the EU and economic recession, but overall it has increased from € 3 million in 2000 to € 13 million in 2011. It can be concluded that expenditures for agriculture have been changed more intense in both increase and decrease of total R&D expenditure in analysed time period, showing a dependence on the overall situation.

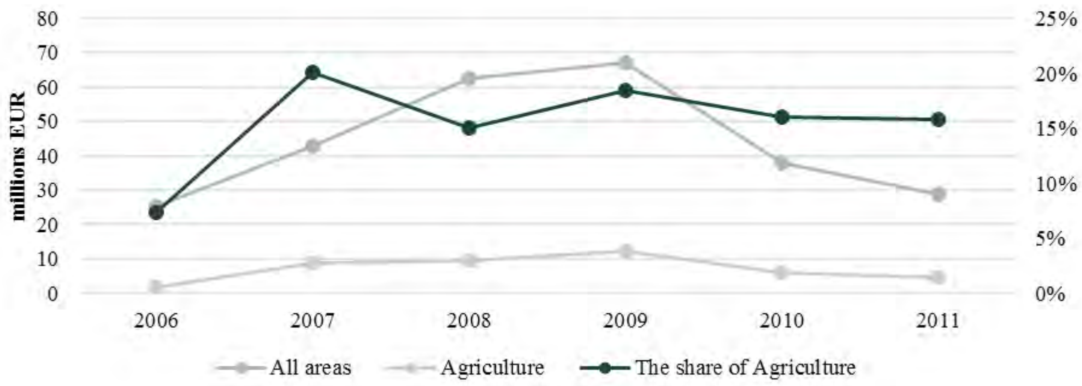
The total R&D expenditure for agriculture in business enterprise, government and higher education sectors are presented in Figure 3, reflecting that EU funding programs have facilitated the increase of R&D expenditure starting from 2004, involving not only government and higher education institutions but business enterprises as well.

The total Government Budget Appropriations or Outlays for R&D (GBAORD) has increased from € 14 million in 2000 till € 67 million in its highest point in 2009. In 2011 the GBAORD were € 29 million, decreasing by 43% comparing with 2009. The share of agriculture (Fig. 4) in the GBAORD is 16% in 2011 (€ 4.5 million); and it has not been substantial changing in thee analysed time period. The total GBAORD for agriculture shows the same tendencies as total GBAORD – the increase from 2006 till 2009 was significant (more than six times), but since then the decrease is observed.



Source: [2]

Figure 3. **R&D for agriculture in business enterprise, government and higher education sectors, 1995-2012**



Source: [2]

Figure 4. **Government Budget Appropriations or Outlays for R&D in Agriculture, 2006-2011**

Overall trends in agricultural research in Latvia

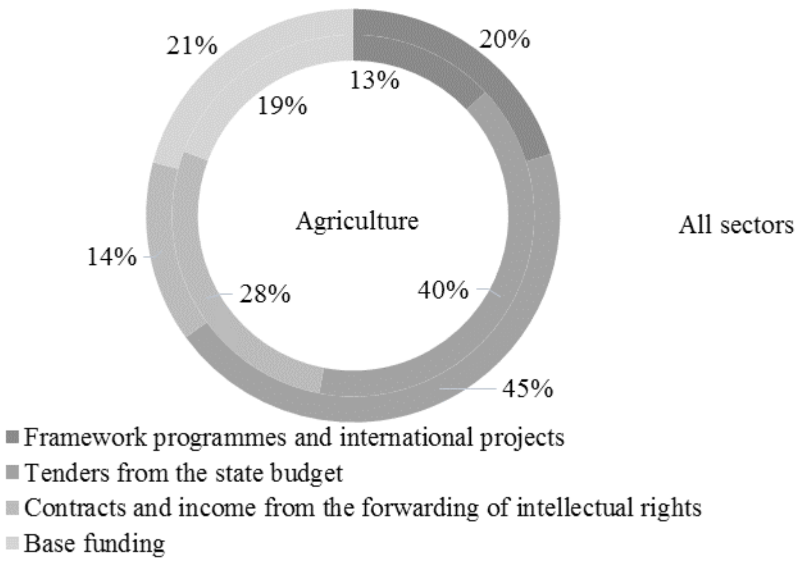
The consultations with the research institutions and the representatives of the Ministry of Agriculture indicated that there is a mutual understanding on the common research topics by the research institutions and the Ministry of Agriculture. When funding scientific projects Ministry of Agriculture is mainly focusing on the topics on which the national results are requested at the EU level within the Common Agriculture Policy or for the National Development Plan at the national level.

Agriculture research is also supported by the State research programme – in 2013 the Latvian government adopted six priority areas in science for the period of 2014-2017; two of these priorities included agricultural sciences and forestry. Thus the share of agricultural and forestry research in the State research programme funding for 2014-2017 is 19% of the financing for all state research programmes which makes a total of 26 million euro [14].

The topics of national research are very much in line with the research priorities of the EU. Still there is no common research strategy and the involvement of private sector in the setting of national research priorities for agriculture research is lacking. In the consultations several directions and research topics were highlighted as relevant although not all of them highly represented by research projects and funded. Among these research directions were: efficient use of natural resources; sustainable intensification; climate change adaptation and mitigation; plant breeding and protection technologies and other topics linked with organic farming, sustainability of farming, biological diversity, precise agriculture, processing and storage technologies of agriculture production etc.

A current research topic in the EU and also in Latvia is knowledge based bio-economy. The Latvian strategy for developing knowledge-based bio-economy is not elaborated jet, but 14 institutions, including the Ministry of Agriculture, Latvia University of Agriculture and several research institutes have developed a Strategic Association for Research in Bioeconomy in 2014 that could be a starting point for the further development of the strategic priorities, and consequently studies on this research topic [13].

The analysis of the publicly available annual reports submitted by all state funded scientific institutions for application to the core public funding and the materials of the Ministry of Education and Science in the aspect of distributed funding in 2014 reviled that on average 19% of funds for scientific institutions in agriculture science comes from the core funding, 13% from framework projects and other international projects, but the highest share of funding (40%) comes from the projects funded from the state budget. Contracts and income from the forwarding of the intellectual rights creates 28% of funds (see Fig. 5). Comparing to the data of all sectors, scientific institutions working in agriculture are less involved in the framework programmes and international projects and also receiving less income in the tenders form the state budget, but comparatively more funds are received from contracts with private sector.



Source: [15]

Figure 5. **Division of funding by funding sources in scientific institutions in 2014, %**

The consultations with the scientific institutions indicated that there is a need for strengthening the cooperation with the practice and the interviewees stated that involvement of practice is stressed in the most project calls for agriculture research. However, interviewees also criticized the national administration of EU Structural Funds because in many cases it is requested to involve enterprises as project partners or beneficiaries, but the bureaucratic procedures during the project implementation are so complicated and time consuming that enterprises and especially farmers are not ready to participate.

It was also stated that responding to financial constraints and government incentives scientific institutions increasingly compete for the EU funds and try to compete also internationally for the funding initiatives available in EU Horizon 2020 Programme, Interreg and other EU research programs and also attraction of private funding. Consequently most of the research is project-based therefore limited in time of the project implementation that is in most cases 2-3 years. The research becomes more fragmented and linked to the funding sources, thus affecting ability to obtain long term data especially typical and needed for agriculture research.

CONCLUSIONS

The Gross domestic expenditure on Research and Development expenditure in Latvia has increased significantly (more than 8 times) since 1995 and the clear impact of overall economic development can be observed. The largest share of this expenditure mainly comes from the higher education sector. Total R&D expenditure for the classification by FOS for Agricultural sciences in Latvia has varied due to macro-economic issues – the accession to the EU and economic recession, but overall it has increased, involving not only government and higher education institutions but business enterprises as well.

The highest share of funding (40%) for scientific institutions in agriculture science comes from the projects funded from the state budget. There contracts and income from the forwarding of the intellectual rights creates 28% of funds. In response to the limited local financial resources, scientific institutions are internationalise their activities and are increasingly attempting to obtain international funding.

The main topics for current and future research are efficient use of natural resources; sustainable intensification; climate change adaptation and mitigation; plant breeding and protection technologies, knowledge based bio-economy and other topics linked with organic farming, sustainability of farming, biological diversity, precise agriculture etc., but as most of the research is project-based, it becomes more fragmented and it is problematic to carry out long term-trials.

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GREENHOUSE GAS EMISSIONS FROM AGRICULTURE

FUNCTIONAL LAND MANAGEMENT FOR MANAGING SOIL FUNCTIONS – THE TRADE-OFF BETWEEN PRIMARY PRODUCTIVITY AND CARBON STORAGE

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Abstract. *The simultaneous demand for food security and sustainability prompted the development of the Functional Land Management Framework (FLM) (Schulte et al., 2014).This is a tool designed to support policy making to manage soil functions to meet the multiple demands on the soil resource. Soil functions are soil-based ecosystem services and FLM focuses on five that are delivered through agriculture. Notably, FLM is designed for use at a national or regional level and is not designed for local level planning or zoning of land use. This research provides a first example of a practical application of the concept relevant to policy stakeholders, wherein the trade-off between two soil functions – 'primary productivity' and 'carbon cycling and storage' is assessed. This is measured in response to the intervention of land drainage systems applied to poorly and imperfectly draining managed grasslands in Ireland.*

This trade-off is examined spatially using integrated mapping within ArcGIS. National level datasets on land use were combined with an indicative drainage map. Drainage class was used as the dominant classifier for soil types. This allowed both the spatial heterogeneity of soil in terms of biophysical constraints/endowments and their complex interaction with land use to be mapped at a national level. Outputs from DNDC biogeochemical modelling based on Irish Soil Information System Data were used to develop an indicative soil organic carbon loss map used to derive the associated CO_2 loss. Application of the Hybrid Soil Moisture Deficit model was used to determine the impact of drainage on productivity to compute the decreased number of days at which soils are untrafficable and this data was used to develop a productivity difference map. These were combined, and the trade-offs explored as a function of the nominal price of 'carbon credits', measured against productivity gains associated with drainage, which based on previous research was set at €5.50 per hectare per day. Although the standard discount period of 30 years wasapplied, a sensitivity analysis was also carried out using variable discount periods.

The research explicitly quantified the trade-offs between these two soil functions. The application of land drainage could potentially yield productivity increases by up to €302.50 $ha^{-1}a^{-1}$ but simultaneously decreases soil carbon stocks. Moreover, the prioritisation and incentivisation of these competing soil functions is primarily a function of the CO_2 price. A clear divergence emerged between the priorities of different stakeholders. At the current CO_2 price, the agronomic benefits are far larger than the monetised environmental costs. Therefore, the incentive is for farmers to drain particularly as the environmental cost does not translate into a change in income, or into a direct and observable change in the quality of the countryside. Even at future projected prices, this finding remains true for almost all of the land area however the sensitivity analysis showed that this is highly dependent on the discount period. Reducing the discount period to ten years, for example, could result in an inverse observation materialising. This scenario could result in incentives for policy makers and legislators to discourage the installation of drainage systems. Finally, this study showed large geographic variation in this environmental cost: agronomic benefit ratio. This could allow for more specific and hence effective prioritization of the two contrasting soil functions.

Key words: *Soil functions, sustainability, policy, ArcGIS.*

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USING A NEW FINNISH ENVIRONMENTAL TECHNOLOGY TO REDUCE ODOUR EMISSIONS FROM MANURE STORAGE AND SPREADING

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Abstract. *According to research literature, the main source of odour in animal farms is the manure. The annoyance of odour, as sensed by the human nose, increases steeply as the temperature of manure gets higher. Especially the odour that is emitted during surface spreading of manure has been found annoying. The way in which the manure is processed has a remarkable effect on its odour. Consequently, treatments that reduce odour emissions from manure could also be the solution to diminish the annoyance during manure spreading.*
The reported research project aims to create practical methods to prove the effect of different new environmental technologies on the odour. During the project, piloting of an odour reducing slurry treatment technique was done on two Finnish pig farms. People with different sensitivities to the annoyance of odour used portable olfactometers to quantify the odour.
The results indicate that the tested slurry treatment unit, Pellon Biosampo™, effectively reduces odour emission from both manure storages and spreading. The odour of treated slurry is significantly lower than that of raw slurry. The odour vanishes more quickly and the character of the odour is less annoying.
Further studies are being done to calculate the economics of odour-reducing technologies.

Key words: *Odour, Reduction, Manure, Storage, Spreading.*

INTRODUCTION

Animal production farms have traditionally been situated in the rural areas well apart from densely populated urban areas. As urban areas grow, new transition zones where farms, urban population and e.g. recreation seek for their own space and how to fit together. Problems arise especially where cultivated fields are situated near urban areas and the farmer wants to use manure as fertilizer to the fields. [1]
According to literature, the main source of odour in animal farms is the manure, and the annoyance of odour increases steeply as the temperature of manure gets higher [2]. The way in which manure is processed has a remarkable effect on its odour. Therefore treatments of manure that aim to reduce odour emission could also be the solution to minimize annoyance during manure spreading.
The research project aims to create practical methods to prove the effect of different new environmental technologies on the odour. In this paper results from the test of one method, the Pellon Biosampo™, are reported.

MATERIALS AND METHODS

Eerola Farm that is situated in the province of South Ostrobothnia in central western coast of Finland was selected as a test location. The pilot farm produces ca. 3000 fattening pigs annually. The farm has recently invested in a manure treatment unit, Pellon Biosampo™ (Fig. 1), which uses patented bacterial digestion and separation technologies to reduce odour and preserve nutrients from the manure. The unit produces two fractions, solid and liquid, that can be used as fertilizer. The solid part is composted. The separated liquid is aerated and treated biologically in 6 separate tanks. Samples from raw slurry, from separated liquid fraction and from the liquid at each treatment tank were taken to find out the reduction of odour in every step.
Odour measurements were performed with a portable olfactometer (Fig. 2). The Nasal Ranger™ olfactometer gives the dilution at which the odor is detected. There is an active carbon filter in the device that removes odor. The odourless filtered air is mixed gradually with more and more of the air to be

evaluated until the test person detects the odour. The result depends on the sensitivity of the test persons so that they are also tested. There were 9 test persons used to evaluate the odour from the 8 different liquid samples.

Both spread liquids were fresh. Raw slurry was taken directly from the buffer storage before the treatment plant and the treated liquid fraction was taken from the last treatment tank. The characterization of the materials is shown in table1.

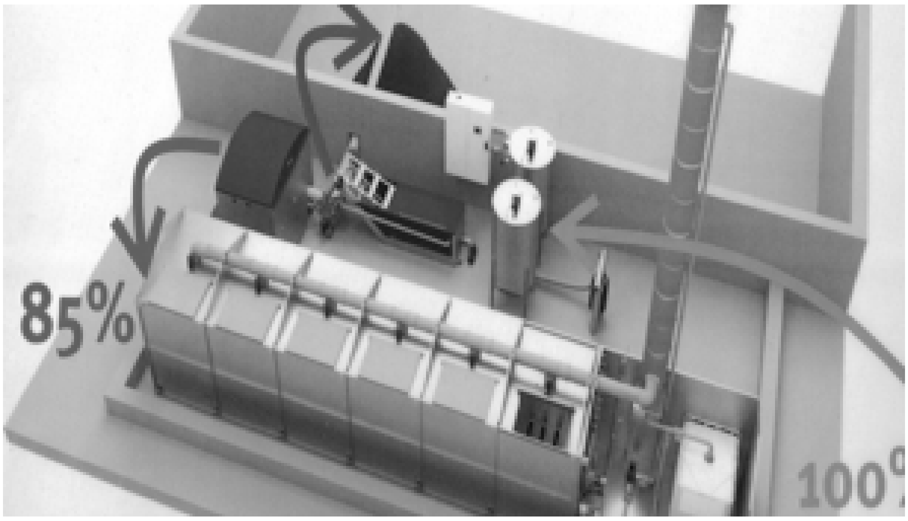


Figure 1. **Manure handling with Biosampo™**

Figure 2. **Odour measurements with Nasal Ranger™ field olfactometer**

Table 1

The nutrient and dry matter content of the raw and treated slurry

	N_{tot} g/kg	N_{sol} g/kg	P g/kg	K g/kg	Total solids, %
Raw slurry	4,1	3,1	0,57	2,4	2,85
Treated liquid	2,9	2,2	0,24	1,8	1,27

Broadcast spreader with a splash plate was used for spreading both the raw slurry and the treated liquid fraction. The spreading area was about 1 ha. The weather was sunny, temperature + 12 °C and wind speed ca. 5 m/s. Measurement were done at all four corners around the spreading area. Rugged temperature, RH and NH_3 sensors and the portable olfactometer Nasal Ranger™ were used (Fig.3).

Figure 3. **Both raw slurry and treated liquid fraction were spread by a broadcast spreader with a splash plate (left). Measurements were done with rugged temperature, RH and NH_3 sensors (right).**

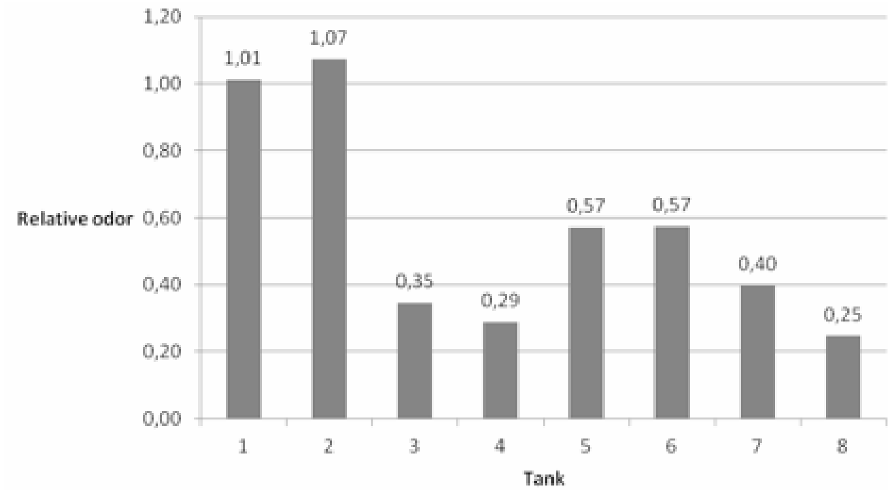
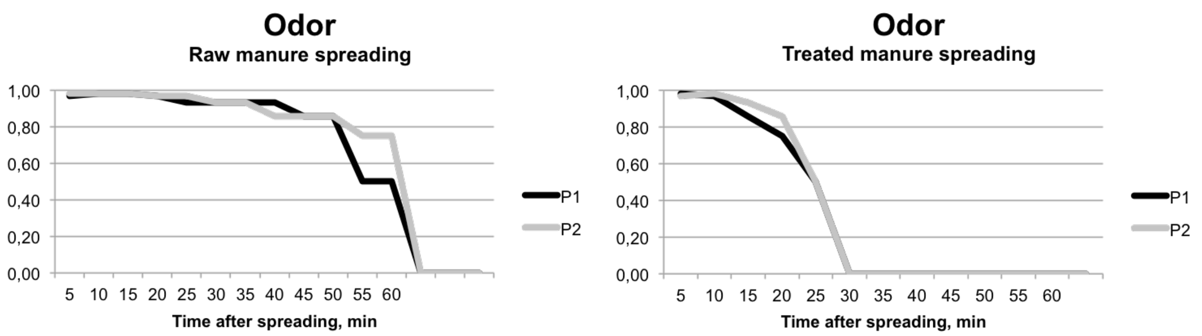


Figure 4. **Reduction of odour along the process in Biosampo™. Relative odor. Raw slurry=1,0. 9 test persons.**



Figuer 5. **Reduction of odour after manure spreading. Raw slurry (left) and treated slurry (right). Calculated as relative odor where initial odour is 1.0.**

RESULTS AND DISCUSSION

The odour of the slurry after separation is the same or even a bit stronger than that of the raw slurry. The odour is significantly lowered already at the first biological treatment tank (number 3) and is lowest at the last treatment tank. (Fig 4). Test persons also identify change on the character of the smell. The manure-like smell changed to a more earth-like smell.

The odour annoyance from spreading of the treated slurry was significantly lower than that of the raw slurry. The initial reading of the olfactometer at the start of spreading was 60 (maximum reading) for both the treated slurry and the raw slurry. The odour of the treated liquid fraction vanished in about 30 minutes while for the odour from raw slurry the time was the double, about 60 minutes (Fig. 5). Also the character of the odour for treated slurry was less annoying. Test persons told that it is more like the odour of soil or wet straw than that of manure.

CONCLUSIONS

The results indicate that the tested slurry treatment unit, Pellon Biosampo™, reduces odour emission from both manure storage and spreading. The odour of treated slurry is significantly lower than that of raw slurry. After surface spreading the odour vanishes more quickly and the character of the odour is far less annoying.

However, it is evident that the pilot system needs further research and development in order to further optimize the process. It is likely that the efficiency of the treatment could be better and the product more usable. However, at this stage, the results are positive and give good basis for further studies.

Further studies are being done to gather wider and deeper evidence of the effect and to calculate the economics of the use the technology. Additional modules that further treat the manure components and fractions are being added to the system that also needs to be tested in further research.

ACKNOWLEDGEMENTS

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CLIMATE CHANGE ADAPTATION IN THE COUNTRYSIDE OF LATVIA: ADAPTATION TOOLS AND USE OF KNOWLEDGE

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Abstract. *Lately it is observed that the climate of Latvia is changed and the periods of heat have become longer. Latvian climate change projections indicate on possible increase in the average temperature in the subsequent 30 years (Economics – the Environment – Growth. Environment and Sustainable Development. M.Klavins, W.Filho, J.Zaloksnis red. Academic Press of University of Latvia, Riga, 2010). In order to ensure sustainable development of Latvia it is necessary to identify vulnerability of agricultural sectors or in controversy, the climate change advantages and make anticipatory adaptation measures.*

Economic, Social and Environmental aspects of climate change adaptation in the agri-environmental management practices are determined and applied knowledge and economic benefit of the adequacy of the potential impacts of climate change in the protection of water and soil, climate change mitigation by limiting emissions and the use of pesticides and biodiversity of the vulnerability of varieties bred and uses local species identification (A European science plan to sustainably increase food security under climate change. Global Change Biology, Vol. 18, No. 11, 2012, p. 3269-3271). In the development of Latvian countryside in the climate adaptation measures, the Agrarian sector is if great importance (farming and agriculture), which, except for some individual large farms, consists of small production units in fragmented rural infrastructure, thus creating unequal applicability of tools and knowledge.

Therefore, in the adaptation to climate change it is necessary to assess the knowledge and attitude of the main involved target groups.

The research focuses on climate change adaptation, based on previous research, theoretical scientific knowledge on climate change adaptation in agricultural sector policies and their updating in Latvia, studying the importance to use the environmental communications tools in the engagement of farms.

The research provides a summary of the information from the interviews and surveys issues as well as case studies.

The results obtained from the research, assess the opinion of target groups on the restrictive and incentive factors in climate change adaptation in Latvian agricultural sector over the next 20 years, changes in the use of agro-economic benefit. The obtained results of the questionnaires and interviews, related to the impact of adaptation measures of the climate change on rural economic model and long-term planning of climate change at the municipal level, were summarized in accordance with the information provided by the target groups and the Business Sector.

Results of a survey of farmers and rural agricultural specialists regarding the financial and economic impacts of climate change have been analysed which shed light on the viability of farming operations in the context of climate change. The results also inform concerning identified opportunities and constraints to adapting agricultural practice and policy to a changing climate.

The study shows that, in order to implement adaptation policies, the following prerequisites are necessary:

- *In the development of agricultural moving towards the interdisciplinary approach: limiting and adaptation measures of climate change must be addressed taking into account the conditions for sustainable agricultural development;*
- *In the most important condition for rural development in climate adaptation policy planning and development of agriculture in general is human capacity building in each of the target groups. It is necessary to improve the knowledge of the involved target groups, providing the agricultural sector's economic efficiency, social and natural environmental quality, attracting skilled experts and scientists.*

Key words: *climate adaptation, agri-environmental management.*

LATVIA'S PROGRESS TOWARDS AGRICULTURAL GHG MITIGATION

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Abstract. *Climate change brings in itself challenges and changes that are urgent for agricultural production both in Latvia and in the entire world. In this context agriculture plays a large role in causing the greenhouse effect and holds a large potential for climate change mitigation. This article aims to evaluate Latvia's progress towards agricultural GHG emissions mitigation. In order to meet the set aim, the research focuses on two key aspects: an evaluation of the present situation in Latvia regarding GHG emissions in agriculture; and analysis of agricultural sector policy in the field of GHG emissions mitigation. Research results shows that agricultural emissions (mainly from crop and livestock production) in Latvia are the second largest emitter of the total greenhouse gas emissions, accounting for 22%. This is a quite alarming indicator, as Latvia ranks third in the EU in terms of proportion of agriculture in total GHG emissions. According to statistical data, the crop sector is presently the largest GHG emitter. However, in order to meet international commitments, management practices for reducing these emissions are required. The research results showed that Latvian agricultural policy envisages number of activities which aims to reduce GHG emissions from agricultural practices.*

Key words: *GHG, mitigation, policy, measures, Latvia.*

INTRODUCTION

Climate change brings in itself challenges and changes that are urgent for agricultural production both in Latvia and in the entire world. Political goals set at various levels [1],[2] and research evidence [3]-[5] indicate that climate-friendly measures have to be introduced in agricultural activity in order to mitigate the negative effects of climate change as well as to adapt to the climate change. According to estimates [6] agriculture plays a large role in causing the greenhouse effect:

– agricultural activities contribute 14% of total global greenhouse gas (GHG) emissions;
– agriculture is the key economic sector producing methane CH_4 and nitrous oxide N_2O (CH_4 and N_2O are the key greenhouse gases being included in the Kyoto Protocol);
– among all the sectors, agriculture in particular has the greatest effect on climate change where emissions from agriculture in 2012 have increased by approximately 19% since 1990.

Agricultural GHG emissions are complex and heterogeneous, but the active management of agricultural systems and emerging technologies offers possibilities for GHG emissions mitigation [7]. Thus agriculture holds a large potential for climate change mitigation.

GHG mitigation measures are not something new and unusual for Latvia, as such measures have been implemented in Latvia's agriculture for a long period.

With the new programming period beginning, the year 2015 has highlighted a number of challenges for Latvia's agriculture that relate to implementing climate- and environmentally-friendly agricultural practices in agricultural activity.

Based on the mentioned considerations, this article aims to evaluate Latvia's progress towards agricultural GHG emissions mitigation. In order to meet the set aim, the research focuses on two key aspects: an evaluation of the present situation in Latvia regarding GHG emissions in agriculture; and analysis of agricultural sector policy in the field of GHG emissions mitigation. Latvia's agricultural sector policies in the context of the GHG emission measures were assessed in the following dimensions:

– Latvia's experience in introducing GHG reduction measures until 2015;
– GHG reduction measures to be planned and introduced in agriculture until 2020.

MATERIALS AND METHODS

To achieve the set aim and tasks of the research, the authors have used the publications and studies of Latvian and foreign scientists; statistical data from the European Environment Agency that covers twenty-two years in the time period from 1990 till 2012.

In order to study the problem elements authors have widely applied several research methods:

- to find out the real situation in Latvia regarding agricultural GHG emissions general scientific methods (analysis and synthesis, monographic) and statistical research methods (calculating statistical indicators, data generalization) were used;
- to analyze agricultural sector policy in the field of GHG emissions mitigation general scientific research methods were used – monographic method, analysis and synthesis, induction and deduction.

RESULTS AND DISCUSSION

Globally, the 21st century brought a number of challenges to be coped with. And climate change is one of the challenges the world's society has to take into consideration, and everything has to be done to improve the current situation. Scientists have proved that the key cause of climate change is the increasing amount of GHG emissions in the atmosphere, which arise from human economic activities [6].

According to statistical information [8] the total amount of GHG emissions in Latvia has significantly decreased since 1990, which was associated with the fast decline in industrial production in the beginning of the 1990s. Yet, since 2001, the GHG emissions have constantly increased, as economic activity rose in the country. If we want to understand what the main sources of GHG emissions are in Latvia – on the whole, the largest GHG emitter is the energy sector (including energy production, energy consumption and the transport sector). However, the second largest emitter is the agricultural sector, accounting for 22% of the total GHG emissions. This is a quite alarming indicator, as Latvia ranks third in the EU in terms of proportion of agriculture in total GHG emissions where Ireland ranks first, followed by Lithuania [9]. Besides, with agricultural activity increasing every year, the amount of GHG emissions rises as well.

According to statistical data [8], the crop sector is presently the largest GHG emitter, which also indicates the increasing trend in GHG emissions. In this case, particularly nitrogen dioxide emissions from fertilisers applied to soils are one of the main sources of GHG emissions (Table 1).

The reason why data summarized in Table 1 are alarming and a special focus has to be placed on agricultural soils management and its relation with GHG emissions is because, with agricultural production intensification increasing and reintegrating the presently unfarmed agricultural area into production, GHG emissions will continue to grow. In this context very topical issue is implementation of measures aiming to reduce GHG emissions from agriculture practice.

In this paper authors have analyzed agricultural sector policy in the field of GHG emissions mitigation and summarized different measures which aim to benefit climate change. According to information summarized in Figure 1 Latvia's farmers have introduced a number of measures for reducing GHG emissions from agricultural activity since 2004.

Table 1

Total GHG emissions from agriculture and their division by sources in Latvia, 1990-2012 (Gg CO_2 eq) and share in average EU28 emissions in 2012 (%)

Source of agricultural GHG emissions	1990	2011	2012	Share in EU28 emissions in 2012, %
Enteric fermentation – cattle (CH_4 emissions, Gg CO_2 eq)	2 065	637	657	0.5
Enteric fermentation – sheep (CH_4 emissions, Gg CO_2 eq)	28	13	14	0.1
Manure management – cattle (CH_4 emissions, Gg CO_2 eq)	67	54	58	0.3
Manure management – swine (CH_4 emissions, Gg CO_2 eq)	118	32	30	0.1
Manure management – solid storage and dry lot (N_2O emissions, Gg CO_2 eq)	564	118	118	0.5
Agricultural soils – direct soil emissions (N_2O emissions, Gg CO_2 eq)	1619	962	1011	1
Agricultural soils – pasture, range and paddock manure (N_2O emissions, Gg CO_2 eq)	358	87	88	0.3
Agricultural soils – indirect emissions (N_2O emissions, Gg CO_2 eq)	1034	389	414	0.5
Total GHG emissions from agriculture (Gg CO_2 eq)	5 853	2 292	2 390	3
Share of agricultural GHG from total GHG emissions (%)	22.51	20.84	21.73	-

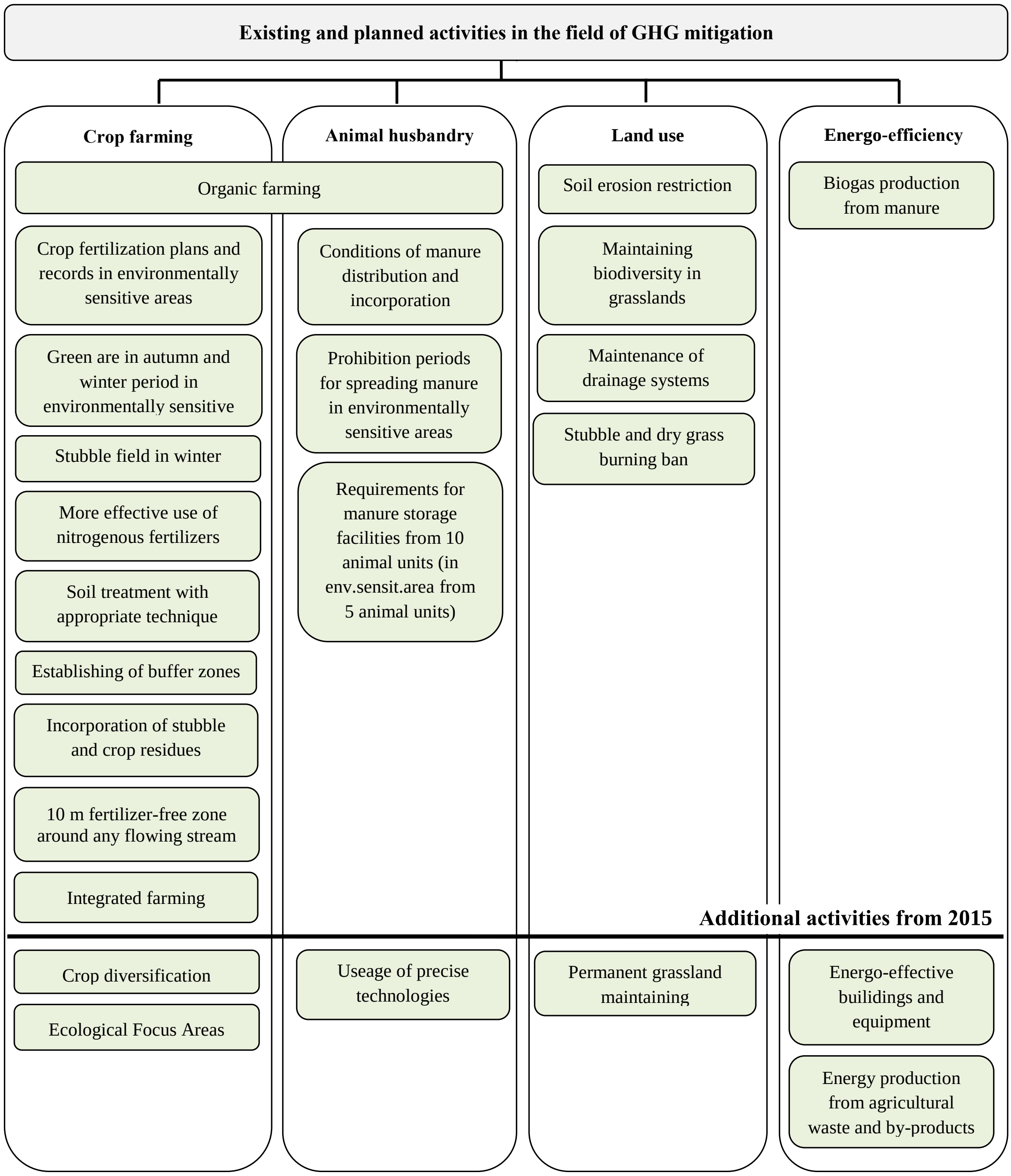

Figure 1. **Agricultural sector policy in the field of GHG mitigation measures in Latvia untill 2015 and additional activities starting from 2015**

Farmers who were eligible for EU direct payments had to comply with the certain requirements as well as measures of the Rural Development Programmes 2004-2006 and 2007-2013, which contributed to good agricultural practices, applied to the agricultural area, and to the environmental situation, including the reduction of GHG emissions. Besides, the introduction of GHG mitigation measures is indirectly affected by the Cabinet regulations that regulate such areas as:

- control of pollution produced by agricultural activity;
- protection of particularly sensitive territories;
- management of manure in livestock buildings;
- biogas production.

The current programming period, i.e. until 2020, also envisages financial support for introducing GHG emission mitigation measures. A special focus will be placed on climate- and environmentally-friendly agricultural practices or the “green component”, which is an extra payment to all beneficiaries of basic payments if corresponding practices are complied with. On the whole, all the above-mentioned measures of Latvia's agricultural policy concerning GHG emission mitigation measures until 2015, as well as planned activities from 2015 are summarised in Figure 1.

From the overall situation analysis it can be concluded that formally Latvian agricultural policy foresees more than 20 different measures related with GHG emission mitigation and covers such areas as crop farming, animal husbandry, land use and energy-efficiency. However, there is lack of scientific evidences and calculations that could show GHG reduction potential of these measures in Latvia, how effective they are; and is there necessity for any additional GHG reduction measures in order to meet international commitments. Such considerations call for further research and more detailed situation assessment in the field of GHG emission mitigation measures.

CONCLUSIONS

1. In Latvia agriculture contributes about 22% of total GHG emissions in CO_2 equivalents in 2012 and due to increased agricultural activity Latvian agricultural GHG emissions show growing trend, i.e. in 2012 amount of agricultural GHG emission increased by 4.3% if compared with 2011.

2. In order to ensure that Latvia will be able to meet Kyoto Protocol target for second commitment period, sustainable management practices for reducing GHG from agriculture need to be developed and adopted. Special focus should be paid on such management practices that tend to mitigate CH_4 emissions from cattle enteric fermentation, N_2O direct emissions from agricultural soils and indirect N_2O emissions from agricultural soils, which currently are the main sources of agricultural GHG emissions in Latvia.

3. Latvian agricultural policy foresees more than 20 different measures related with GHG emission mitigation and covers such areas as crop farming, animal husbandry, land use and energy-efficiency. However, there is lack of scientific evidences and calculations that could show GHG reduction potential of these measures in Latvia.

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METHANE FROM ENTERIC FERMENTATION OF LIVESTOCK IN LATVIA

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Abstract. *Latvia reports emissions from cattle (including dairy cows), sheep, swine, goats, horses, rabbits, and fur-bearing animals. Emissions from poultry enteric fermentation have not been estimated. According to 2006 IPCC Guidelines methodology for enteric fermentation calculation from poultry are not developed. However methane emission from poultry is calculated below in the Manure management category. Cattle are the largest source of enteric methane emissions (95.2% from total methane emissions from enteric fermentation) in Latvia. In 2013, dairy cattle produced 64.5% and non-dairy cattle – 30.7% of methane emissions. Emission from sheep made 2.1%, swine – 1.7%, horses – 0.6%, and goats – 0.2% of the total emission from enteric fermentation. In 2013, methane emissions from enteric fermentation of domestic livestock increased by 0.11 Gg or 3.6%, if to compare with 2012. This is caused by the increase of the number of all livestock, excepting goats and horses. The number of non-dairy livestock increased up to 5.7% in 2013. Since 1990 generally due to evident fall of the number of livestock emissions methane emmisions decreased by 64.9%.*

Key words: *methane, enteric fermentation, livestock.*

INTRODUCTION

Naturally occurring greenhouse gases consist of water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). Carbon dioxide, CH_4 and N_2O have a direct global warming effect, and their concentrations in the atmosphere are the result of human activities. Methane makes up 7.9% of all emissions. The major sources include landfills, natural gas systems, enteric fermentation (dairy and beef cattle primarily), and coal mining. According to the Intergovernmental Panel on Climate Change (IPCC), methane is more than 20 times as effective as CO_2 at trapping heat in the atmosphere. The concentration of CH_4 in the atmosphere the past two centuries has increased by 143%. Methane from enteric (microbial) fermentation represents 20% and manure management 7% of the total CH_4 emitted. Ruminants (beef, dairy, goats, and sheep) are the main contributors to CH_4 production [1],[3] Ruminant livestock can produce 250 to 500 L of methane per day. The ruminant animal is unique because of its four stomach compartments: reticulum, rumen, omasum and abomasum. The rumen is a large, hollow muscular organ where microbial fermentation occurs. The function of the rumen as a fermentation vat and the presence of certain bacteria promote the development of gases. These gases are found in the upper part of the rumen with CO_2 and CH_4 making up the largest portion: hydrogen 0.2%, oxygen 0.5%, nitrogen 7.0%, methane 26.8%, carbon dioxide 65.5%. The proportion of these gases is dependent on rumen ecology and fermentation balance. Typically, the proportion of carbon dioxide is two to three times that of CH_4, although a large quantity of CO_2 is reduced to CH_4 [3].

MATERIALS AND METHODS

Emissions from enteric fermentation of domestic livestock in Latvia have been calculated by using the IPCC Tier 1 and Tier 2 methodologies presented in the *2006 IPCC Guidelines*. Methane emissions from enteric fermentation for sheep, swine, goats, horses, rabbits and fur-bearing animals have been calculated with the IPCC Tier 1 methodology by multiplying the number of the animals in each category with the IPCC default emission factor of the respective livestock category as shown in *2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines*. Volume 4, Chapter 10): The default emission factors as for developed countries according to *2006 IPCC Guidelines (2006 IPCC Guidelines*. Volume 4, Chapter 10) were used to calculate methane emissions from enteric fermentation for sheep, swine, goats, horses, rabbits and fur-bearing animals (Table 1). As default IPCC or national emission factors for rabbits and fur-bearing animals are not available, the Norwegian (Greenhouse gas emission in Norway 1990-2011, National inventory report, 2013, p. 238) emission factor for fur-bearing animals and Russian emission factors for rabbits were used for emission calculations similarly by neighbouring countries.

Table 1

Default methane emission factors from Enteric Fermentation

Livestock category	EF (kg CH_4 head^{-1} yr^{-1})
Sheep	8
Swine	1.5
Goats	5
Horses	18
Rabbits	0.59
Fur-bearing animals	0.1

Table 2

Methane emissions (Gg) from Enteric Fermentation by livestock category, 1990-2013

Year	Dairy cattle	Non-dairy cattle	Sheep	Swine	Goats	Horses	Rabbits	Fur-bearing animals	Total, CH_4
1990	52.92	33.96	1.32	2.10	0.03	0.56	0.11	0.03	91.02
1991	51.52	31.98	1.47	1.87	0.03	0.54	0.13	0.03	87.57
1992	44.85	24.88	1.32	1.30	0.03	0.51	0.12	0.03	73.03
1993	32.6	12.28	0.91	0.72	0.03	0.47	0.10	0.03	47.14
1994	29.67	8.97	0.69	0.75	0.04	0.48	0.09	0.02	40.72
1995	28.34	9.21	0.58	0.83	0.04	0.49	0.09	0.02	39.60
1996	27.24	8.89	0.44	0.69	0.04	0.46	0.08	0.02	37.87
1997	27.16	8.07	0.33	0.64	0.04	0.42	0.06	0.01	36.73
1998	25.37	7.23	0.24	0.63	0.05	0.40	0.06	0.01	33.98
1999	21.53	6.47	0.22	0.61	0.04	0.34	0.04	0.01	29.25
2000	21.55	6.04	0.23	0.59	0.05	0.36	0.07	0.01	28.90
2001	22.39	6.39	0.23	0.64	0.06	0.35	0.09	0.01	30.16
2002	21.69	6.81	0.25	0.68	0.07	0.33	0.08	0.01	29.93
2003	21.02	7.43	0.31	0.67	0.08	0.28	0.09	0.01	29.87
2004	20.39	6.86	0.31	0.65	0.07	0.28	0.08	0.01	28.66
2005	20.69	7.42	0.33	0.64	0.07	0.25	0.06	0.01	29.48
2006	20.68	7.43	0.33	0.63	0.07	0.24	0.05	0.02	29.45
2007	20.84	8.45	0.43	0.62	0.07	0.23	0.06	0.02	30.71
2008	20.05	8.17	0.54	0.58	0.06	0.24	0.03	0.02	29.69
2009	19.67	8.37	0.57	0.56	0.07	0.23	0.03	0.02	29.50
2010	19.71	8.57	0.61	0.58	0.07	0.22	0.02	0.02	29.80
2011	19.79	8.68	0.64	0.56	0.07	0.21	0.02	0.02	29.98
2012	20.14	9.19	0.67	0.53	0.07	0.20	0.02	0.02	30.84
2013	20.62	9.80	0.68	0.55	0.06	0.19	0.02	0.02	31.95
Share of total % in 2013	64.50%	30.70%	2.10%	1.70%	0.20%	0.60%	0.10%	0.10%	100.00%
2013 versus 2012	+2.40%	+6.60%	+1.40%	+3.50%	-5.30%	-1.80%	+4.30%	0.00%	+3.60%

The Tier 2 methodology has been used for cattle, because emissions from cattle make the biggest part of total agricultural sector methane emissions. With the Tier 2 methodology methane emissions have been calculated as in the Tier 1 methodology, but the emission factors (EF) for dairy cattle and non-dairy cattle has been calculated according to *2006 IPCC Guidelines (2006 IPCC Guidelines*. Volume 4, Chapter 10): Feed digestibility (DE) 65% is used in calculation according average value represented in the *2006 IPCC Guidelines*, because detailed information on feed digestibility are not available in the country yet. The calculation of GE is strongly based on the milk production and fat content in milk.

RESULTS AND DISCUSSION

Methane (CH_4) is emitted as a by-product of the normal livestock digestive process, in which microbes resident in the animal's digestive system ferment the feed consumed by the animal. This fermentation process is also known as enteric fermentation. Ruminant livestock (cattle, sheep and goats) are primary source of methane emissions. The amount of enteric methane emitted is driven primarily by the number and size of domestic animals, the type of digestive system, and the type and amount of feed consumed (IPCC GPG, 2000). Latvia reports emissions from cattle (including dairy cows), sheep, swine, goats, horses, rabbits, and fur-bearing animals (Table 2). Emissions from poultry enteric fermentation have not been estimated. According to 2006 IPCC Guidelines methodology for enteric fermentation calculation from poultry are not developed. However methane emission from poultry is calculated below in the Manure management category.

Cattle are the largest source of enteric methane emissions (95.2% from total methane emissions from enteric fermentation) in Latvia. In 2013, dairy cattle produced 64.5% and non-dairy cattle – 30.7% of methane emissions. Emission from sheep made 2.1%, swine – 1.7%, horses – 0.6%, and goats – 0.2% of the total emission from enteric fermentation. In 2013, methane emissions from enteric fermentation of domestic livestock increased by 0.11 Gg or 3.6%, if to compare with 2012. This is caused by the increase of the number of all livestock, excepting goats and horses. The number of non-dairy livestock increased up to 5.7% in 2013. Since 1990 generally due to evident fall of the number of livestock emissions methane emmisions decreased by 64.9% (Table 2). There has been a lot of research conducted in Europe, Canada, Australia, and the U.S. on strategies to reduce methane emissions from dairy and beef operations. The main focus has been on nutritional strategies, especially cows grazing pasture. Some dietary practices that have been shown to reduce CH_4 include the addition of ionophores, fats, the use of high quality forages, and the increased use of grains [1]-[4]. These nutritional strategies reduce CH_4 through the manipulation of ruminal fermentation, direct inhibition of the methanogens and protozoa, or by a redirection of hydrogen ions away from the methanogens. Relatively new mitigation options have been investigated and include the addition of such additives as probiotics, acetogens, bacteriocins, organic acids, and plant extracts (i.e. condensed tannins). For the long term approach, genetic selection of cows that have improved feed efficiency is a possibility. The following gives more detail about some of the strategies that reduce CH_4: 1) Increasing the efficiency in which animals use nutrients to produce milk or meat can result in reduced CH_4 emissions. This can be accomplished by feeding high quality, highly digestible forages or grains. However, the emissions produced in producing and/or transporting the grain or forage should be considered. 2) Rumen modifiers such as ionophores improve dry matter intake efficiency and suppress acetate production, which results in reducing the amount of hydrogen released. In some of the published research, CH_4 has been reduced by 10%, however the effect of the ionophores have been short-lived in respect to CH_4 reduction [6]. More research on the continued use of ionophores for this purpose is needed. 3) The grinding and pelleting of forages can reduce emissions by 40%, however the costs associated with this practice may be prohibitive. 4) Dietary fats have the potential to reduce CH_4 up to 37% [5]. This occurs through biohydration of unsaturated fatty acids, enhanced propionic acid production, and protozoal inhibition [1],[2]. The effects are variable and lipid toxicity to the rumen microbes can be a problem. This strategy can affect milk components negatively and result in reduced income for the producer. There are several novel approaches to reducing CH_4 that are not very practical at this point. An example would be the defaunation of the rumen. Removing protozoa has been demonstrated to reduce CH_4 emissions by 20% [1],[2]. There may be opportunities to develop strategies that encourage acetogenic bacteria to grow so they can perform the function of removing hydrogen instead of the methanogens. Acetogens convert carbon dioxide and hydrogen to acetate, which the animal can use as an energy source. There is also research being conducted to develop a vaccine, which stimulates antibodies in the animal that are active in the rumen against methanogens. The problems with some of these mitigation strategies to reduce CH_4 are potential toxicity to the rumen microbes and the animal, short-lived effects due to microbial adaptation, volatility, expense, and a delivery system of these additives to cows on pasture [1],[2].

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The research was done on financial support of project "Agricultural sector GHG emissions calculation methods and data analysis with the modeling tool development, integrating climate change".

CONCLUSION

1. Cattle are the largest source of enteric methane emissions (95.2% from total methane emissions from enteric fermentation) in Latvia.

2. In 2013, dairy cattle produced 64.5% and non-dairy cattle – 30.7% of methane emissions of the total emission (31.95 Gg) from enteric fermentation.

3. In 2013, methane emissions from enteric fermentation of domestic livestock increased by 0.11 Gg or 3.6%, if to compare with 2012.

4. Since 1990 generally due to evident fall of the number of livestock emissions methane emmisions decreased by 64.9%.

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CALCULATION METHODOLOGY FOR CATTLE MANURE MANAGEMENT SYSTEMS BASED ON THE 2006 IPCC GUIDELINES

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Abstract. *The paper explains a methodology developed at Latvia University of Agriculture for calculating a percentage distribution for cattle manure management systems based on the 2006 IPCC recommendations. Calculations are based on the following input data: legal information on the output of manure and the dry content of manure, the length of grazing period, the size of herd at which transition from farmyard manure to liquid manure takes place as well as statistical data on the number of cattle and the amount of manure used for biogas production.*
Computer programs developed earlier may be conveniently employed for performing calculations.

Key words*: cattle, manure management system, percentage distribution of manure.*

INTRODUCTION

Since 1990, annual data on potential greenhouse gas (GHG) emissions from various economic activities, including manure management, has been collected in Latvia [1]. Previous GHG inventory data included seven groups of agricultural animals: cows, cattle, pigs, poultry, sheep, goats and horses. All kinds of manure management systems are divided into four groups: liquid manure, farmyard manure, pastures and manure for biogas production.
Yet, at present, a new GHG emission calculation methodology is introduced in Latvia in accordance with the 2006 IPCC Guidelines [2]. For this reason, a much more detailed percentage distribution of the kinds of manure management systems than the ones available in previous research studies and statistical summaries is necessary.
One of the most important groups of agricultural animals is cattle. According to the information available in the database of the Central Statistical Bureau of the Republic of Latvia [3],[4], 406 500 cattle, including 165 000 milk cows were registered in the country in 2013. However, according to national forecasts, the number of cattle might considerably increase.
At the same time, the percentage distribution of this group of agricultural animals has changed. Before 10-20 years, mostly milk cows were kept in Latvia, whereas at present a great focus is being placed on raising meat cattle. The reason is because hilly agricultural areas overgrown with shrubs that are not suitable for growing agricultural crops are exploited for grazing such cattle. And there are a lot of such agricultural areas, which are unsuitable for crops, in Latvia.
The manure management systems used in practice have changed. Earlier, milk cows were mainly stanchioned, producing farmyard manure, whereas now there is a gradual transition to keeping cattle unstanchioned and producing liquid manure.
Another novelty being observed in Latvia since 2007 is the production of biogas by partially using the manure of agricultural animals for this purpose, and at present approximately 40 biogas facilities are in operation in the country [5]. This factor additionally affects changes in GHG emissions and has to be taken into consideration in GHG emission calculations.
Accordingly, the aim of the present paper is to present a new methodology developed at Latvia University of Agriculture for calculating a percentage distribution for cattle manure management systems based on the 2006 IPCC Guidelines. Yet, in a similar way, a percentage distribution of manure may be calculated for other groups of agricultural animals.

MATERIALS AND METHODS

Based on the recommendations given in the 2006 IPCC Guidelines [2] and on the authors' considerations, cattle have to be classified into four separate subgroups that involve four kinds of manure management systems (Table 1).

Table 1

Cattle classification and the kinds of manure management systems

Cattle group	Manure management systems				Notes
	Pastures	Farmyard manure	Liquid manure, slurry	Anaerobic fermentation	
Milk cows	x	x	x	x*	Farmyard manure is produced on small farms and cows are put out to graze. Large farms produce liquid manure and do not exploit their pastures.
Calves of milk cows and young cattle less than 2 years of age	x	x		x*	Farmyard manure is produced; small farms put their young cattle out to graze from 6 months of age
Suckling cows and breeding bulls	x	x			Livestock are put out to graze in summer, while in winter the livestock are kept in sheds with bedding
Calves of suckling cows and young cattle less than 2 years of age	x	x			

* manure only from milk cow sheds where cows are kept unstanchioned in stalls are used for anaerobic fermentation

Further, the research is based on the following considerations:

- for calculations on manure management systems, first, the distribution of farmyard manure, liquid manure and manure left on pastures has to be identified, and only then the share of manure to be used for biogas production is calculated;
- solutions to keeping animals and producing manure are different for each cattle group; therefore the distribution of manure for each group has to be calculated by different formulas, given the specifics of keeping the animals of corresponding group.

For the milk cow group, a percentage distribution of manure management systems may be calculated as follows:

$$\lambda_{g.gan} = \frac{M_{g.gan}}{\sum M_g} \cdot 100,\ \lambda_{g.pak} = \frac{M_{g.pak}}{\sum M_g} \cdot 100,\ \lambda_{g.sk} = \frac{M_{g.sk}}{\sum M_g} \cdot 100, \quad (1, 2, 3)$$

where: $\lambda_{g.gan}$, $\lambda_{g.pak}$, $\lambda_{g.sk}$ – percentage distribution of cow manure: the shares of manure left on pastures, of farmyard manure and liquid manure, %;

$M_{g.gan}$, $M_{g.pak}$, $M_{g.sk}$ – amounts of manure left on pastures and of farmyard and liquid manure from cow sheds, t/year;

$\sum M_g$ – total amount of manure from milk cows, t/year.

A total amount of manure from milk cows is calculated by the following formula:

$$\sum M_g = M_{g.gan} + M_{g.pak} + M_{g.sk}, \quad (4)$$

An amount of manure left on pastures, given the fact that only the cows being kept stanchioned in a shed, producing farmyard manure, are put out to graze, is calculated as follows:

$$M_{g.gan} = k_{g.gan} \cdot Z_g \cdot \frac{\chi_{g.pak}}{100} \cdot q_{g.pak} \cdot \frac{S_{g.sv}}{S_{g.pak}}, \quad (5)$$

where: $k_{g.gan}$ – pasture utilisation rate;

Z_g – total number of cows, according to statistical data [3],[4];
$\chi_{g.pak}$ – proportion of cows producing farmyard manure, %;
$q_{g.pak}$ – output of farmyard manure at the average national milk yield, t/year;
$S_{g.sv}$, $S_{g.pak}$ – average dry matter of fresh manure (the mix of faeces and urine) as well as of farmyard manure, %.

A pasture utilisation rate is calculated as follows:

$$k_{g.gan} = \frac{t_{g.gan}}{24 \cdot 365}, \tag{6}$$

where: t_{gan} – average length of grazing period for cows, h/year.

A proportion of cows producing farmyard manure is obtained as follows:

$$\chi_{g\ pak} = \frac{Z_{g.pak}}{Z_g} \cdot 100, \tag{7}$$

where: $Z_{g.pak}$ – number of cows producing farmyard manure in the country.

However, $\chi_{g.pak}$ may be calculated based on statistical data if knowing the size of herd at which transition from keeping cattle unstanchioned to keeping them stanchioned, i.e. transition from farmyard manure to liquid manure, takes place. The following formula may be used for this purpose:

$$\chi_{g.pak} = \chi_{g.pak.1} + \chi_{g.pak.2} + \ldots + \chi_{g.pak.n}, \tag{8}$$

where: $\chi_{g.pak1}$; $\chi_{g.pak2}$; $\chi_{g.pak.n}$ – percentages of cows in the herd's first group, second group and n-th group that produce farmyard manure (based on the distribution of cows by herd size available in statistics) [3],[4].

An amount of farmyard manure from milk cows is calculated as follows:

$$M_{g.pak} = (1 - k_{g.gan}) \cdot \frac{\chi_{g.pak}}{100} \cdot Z_g \cdot q_{g.pak}, \tag{9}$$

An amount of liquid manure from milk cows is obtained as follows:

$$M_{g.sk} = (1 - \frac{\chi_{g.pak}}{100}) \cdot Z_g \cdot q_{g.sk}, \tag{10}$$

where: $q_{g.sk}$ – output of liquid manure per cow, t/year.

Based on the formulas (4, 5, 9 and 10), one can obtain the following equation:

$$\sum M_g = \frac{k_{g.gan} \cdot \chi_{g.pak} \cdot Z_g \cdot q_{g.pak} \cdot S_{g.sv}}{100 \cdot S_{g.pak}} + \frac{(1 - k_{g.gan}) \cdot \chi_{g.pak} \cdot Z_g \cdot q_{g.pak}}{100} + (1 - \frac{\chi_{g.pak}}{100}) \cdot Z_g \cdot q_{g.sk}, \tag{11}$$

a share of manure left on pastures, %:

$$\lambda_{g.gan} = \frac{100 \cdot k_{g.gan} \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.sv}}{k_{g.gan} \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.sv} + S_{g.pak}[(1 - k_{g.gan}) \cdot \chi_{g.pak} \cdot q_{g.pak} + (100 - \chi_{g.pak}) \cdot q_{g.sk}]}, \tag{12}$$

a share of farmyard manure, %:

$$\lambda_{g.pak} = \frac{100 \cdot (1-k_{g.gan}) \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.pak}}{k_{g.gan} \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.sv} + S_{g.pak}[(1-k_{g.gan}) \cdot \chi_{g.pak} \cdot q_{g.pak} + (100-\chi_{g.pak}) \cdot q_{g.sk}]}, \tag{13}$$

and a share of liquid manure, %:

$$\lambda_{g.sk} = \frac{100 \cdot (100-\chi_{g.pak}) \cdot q_{g.sk} \cdot S_{g.pak}}{k_{g.gan} \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.sv} + S_{g.pak}[(1-k_{g.gan}) \cdot \chi_{g.pak} \cdot q_{g.pak} + (100-\chi_{g.pak}) \cdot q_{g.sk}]}. \tag{14}$$

The group of calves of milk cows and young cattle produces farmyard manure, but a part of the manure is left on pastures. Therefore, a total amount of manure is obtained as follows:

$$\sum M_{g.t} = M_{g.t.gan} + M_{g.t.pak}, \tag{15}$$

where: $M_{g.t..gan}$, $M_{g.t.pak}$ – amount of manure left on pastures and, accordingly, an amount of farmyard manure from calves of milk cows and young cattle less than 2 years of age, t/year.

An amount of manure left on pastures, given the fact only the calves of milk cows being kept stanchioned in a shed and young cattle are put out to graze:

$$M_{g.t.gan} = k_{g.t.gan} \cdot \frac{\chi_{g.pak}}{100} \cdot Z_{g.t} \cdot q_{g.t.pak} \cdot \frac{S_{g.t.sv}}{S_{g.t.pak}} \tag{16}$$

where: $k_{g.t.gan}$ – pasture utilisation rate for calves of milk cows and young cattle (calculated by Formula 7);
$Z_{g.t}$ – total number of calves and young cattle, based on statistical data;
$q_{g.t.pak}$ – average weighted output of farmyard manure from calves and young cattle of corresponding group, t/year;
$S_{t.j.sv}$, $S_{t.j.pak}$ – average dry matter of fresh manure (the mix of faeces and urine) as well as of farmyard manure for calves of milk cows and young cattle, %.

An amount of farmyard manure is derived as follows:

$$M_{g.t.pak} = (1-k_{g.t.gan}) \cdot \frac{\chi_{g.pak}}{100} \cdot Z_{g.t} \cdot q_{g.t.pak} \cdot \frac{S_{g.t.sv}}{S_{g.pak}} + (1-\frac{\chi_{g.pak}}{100}) \cdot Z_{g.t} \cdot q_{g.t.pak}, \tag{17}$$

Based on the formulas (15, 16 and 17), one can calculate a share of manure left on pastures, %:

$$\lambda_{g.t..gan} = \frac{100 \cdot k_{g.t.gan} \cdot \chi_{g.pak} \cdot S_{g.t.sv}}{\chi_{g.pak} \cdot S_{g.t.sv} + (100-\chi_{g.pak}) \cdot S_{g.t.pak}}. \tag{18}$$

and a share of farmyard manure, %:

$$\lambda_{g.t.pak} = 100 - \lambda_{g.t.gan}. \tag{19}$$

Suckling cows and breeding bulls graze in pastures and stay in pasture sheds. Therefore they produce both farmyard manure and pasture manure, and in this case the distribution of manure is mainly determined by the pasture utilisation rate.
A total amount of manure:

$$\sum M_{l} = M_{l.gan} + M_{l.pak}, \tag{20}$$

where: $M_{l.gan}$, $M_{l.pak}$ – amounts of pasture manure and farmyard manure from suckling cows and breeding bulls, t/year.

An amount of manure left on pastures, t/year:

$$M_{l.gan} = k_{l.gan} \cdot Z_l \cdot q_{l.pak} \cdot \frac{S_{l.sv}}{S_{l.pak}} \tag{21}$$

where: $k_{l.gan}$ – pasture utilisation rate;
Z_l – total number of cattle of corresponding age group, based on statistical data;
$q_{l.pak}$ – average weighted output of farmyard manure from cattle of corresponding group, t/year;
$S_{l.sv}$, $S_{l.pak}$ – average dry matter of fresh manure (the mix of faeces and urine) as well as of farmyard manure for calves of milk cows and young cattle, %.

An amount of farmyard manure, t/year:

$$M_{l.pak} = (1 - k_{l.gan}) \cdot Z_l \cdot q_{l.pak}, \tag{22}$$

Based on the formulas (20, 21 and 22), one can obtain the following equation:

$$\sum M_l = \frac{Z_l[k_{l.gan} \cdot q_{l.pak} \cdot S_{l.sv} + (1 - k_{l.gan}) \cdot q_{l.pak} \cdot S_{l.pak}]}{S_{l.pak}} \tag{23}$$

Therefore, a share of manure left on pastures, %, is derived as follows:

$$\lambda_{l.gan} = \frac{100 \cdot k_{l.gan} \cdot S_{l.sv}}{k_{l.gan} \cdot S_{l.sv} + (1 - k_{l.gan}) \cdot S_{l.pak}}, \tag{24}$$

and a share of farmyard manure, %:

$$\lambda_{l.pak} = \frac{100 \cdot (1 - k_{l.gan}) \cdot S_{l.pak}}{k_{l.gan} \cdot S_{l.sv} + (1 - k_{l.gan}) \cdot S_{l.pak}} \tag{25}$$

Calves of suckling cows and young cattle, just like suckling cows and breeding bulls, graze in pastures and stay in pasture sheds. Therefore they also produce both farmyard manure and pasture manure, and the distribution of their manure may be calculated by similar formulas as in the previous case.

Calculation of the share of manure for biogas production. Liquid manure from milk cows as well as farmyard manure from calves and young cattle available in cattle sheds is used for biogas production. Manure from small milk cow sheds where livestock are kept stanchioned and therefore only farmyard manure is produced is not used for this purpose. Also, manure from meat cattle is not used for biogas production, as the largest share of this manure is left on pastures.

To calculate the share of manure used for biogas production for each cattle group included in Table 1, the amount of manure used for biogas production and the amount of manure obtained from each cattle group to be used for biogas production have to be known.

According to data provided by the Rural Support Service (RSS) [5], the total amount of cattle manure used for biogas production was estimated at 395150 t in 2013. Assuming that the amount of manure used for biogas production is proportional to the amount of manure from each cattle group, one can derive the following equation.

$$\psi_g = \psi_{g.t} = \frac{M_{b.l}}{M_{g.sk} + (100 - \chi_{g.pak}) \cdot M_{g.t.pak}}, \tag{26}$$

where: $\psi_{g.}$, $\psi_{g.t}$ – ratios specifying the share of manure from milk cows as well as calves and young cattle that is used for biogas production;

$M_{b.l}$ – amount of cattle manure used for biogas production, based on RSS data, t/year;
$M_{g.sk}$ – amount of liquid manure from milk cows, i.e. cows kept in stalls, t/year;
$M_{g.t.pak}$ – amount of farmyard manure from calves of milk cows and young cattle, t/year.

Therefore, a share of liquid manure from milk cows used for biogas production, %, is derived as follows:

$$\lambda_{b.g.sk} = \psi_g \cdot \lambda_{g.sk}, \quad (27)$$

but a share of farmyard manure from calves of milk cows and young cattle, %:

$$\lambda_{b.g.t.pak} = \psi_{g.t} \cdot (1 - \frac{\chi_{g.pak}}{100}) \cdot \lambda_{g.t.pak}. \quad (28)$$

RESEARCH RESULTS

Data on the number of cattle and their distribution by herd size for 2013 provided by the Central Statistical Bureau [3],[4], information on the amount of manure used for biogas production provided by the Rural Support Service [5], information on the length of grazing period for cattle available in literatures [6],[7] as well as data on the output of manure and the content of dry matter for various species of agricultural animals given in Cabinet Regulation No 829 [8] were used to test the developed methodology.
The calculations on the share of cattle manure used for biogas production are summarised in Table 2.

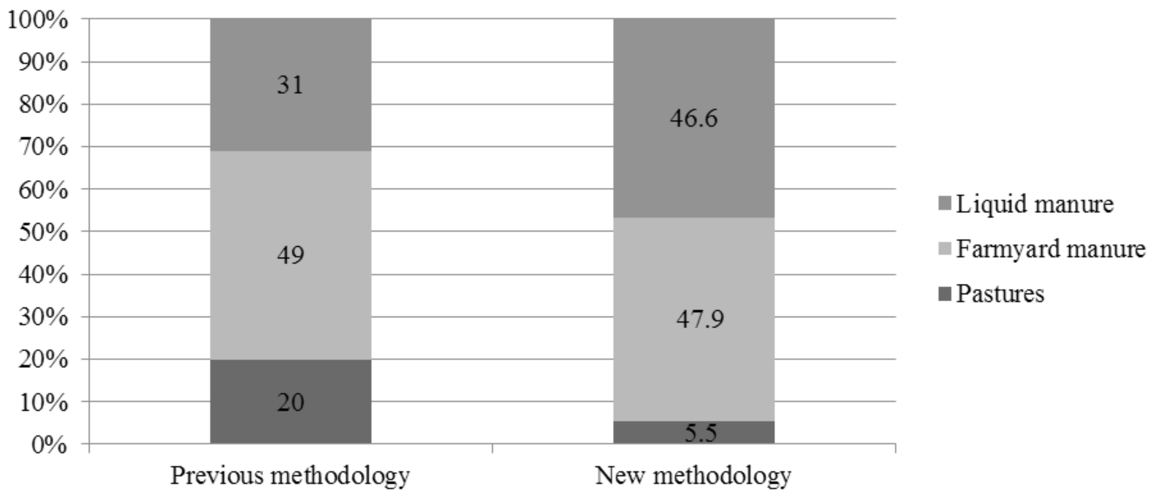
Table 2

Share of manure for biogas production and the amounts of manure produced (based on 2013 data)

Agricultural animal group	Number of animals whose manure may be used for biogas production, thou	Average output of manure		Share of manure used for biogas production, ratio ψ
		per animal, t/year	total, thou t	
Milk cows*	49.52	19.0	940.9	0.29
Young cattle (1-2 years of age)**	19.80	9.0	178.2	
Calves (less than 1 year of age)**	38.00	7.0	266.0	

* cows producing liquid manure
** only the calves of milk cows and young cattle producing liquid manure

The distribution of manure calculated by the authors is presented in Figure 1.



Note: in the calculations the pasture utilisation rate was assumed to be 0.16 for milk cows and 0.50 for meat cattle (these data will be made more precise in further research studies by the authors); transition from farmyard manure to liquid manure, according to unpublished research studies by the authors, takes place at the herd size of 65 cows

Figure 1. **Percentage distribution of the cattle manure management systems (2013)**

As shown in Figure 1, farmyard manure accounted for the highest share among all the groups of cattle in 2013. More than 30% of the manure from meat cattle was left on pastures, while for milk cows as well as calves and young cattle it was 5.5% and 7.6%, respectively. The production of biogas consumed 13.5% of the liquid manure from milk cows and 26.8% of the farmyard manure from calves of milk cows and young cattle.

CONCLUSIONS

1. A methodology was developed for calculating a percentage distribution for cattle manure management systems based on data on the output of manure and the dry content of manure, the length of grazing period, the size of herd at which transition from farmyard manure to liquid manure takes place as well as the amount of manure used for biogas production. Part of the data may be obtained from legal documents and annual statistical reports, while the length of grazing period and the marginal size of herd at which transition from farmyard manure to liquid manure takes place can be identified through research studies.

2. The developed calculation methodology can serve as a basis for designing computer programs that can significantly facilitate the necessary calculations.

3. The calculations revealed that in 2013, approximately a half, or even more, of the manure from each group of cattle represented farmyard manure. Approximately 35% of the manure from meat cattle was left on pastures, while the production of biogas consumed 13.5% of the liquid manure from milk cows and 26.8% of the farmyard manure from calves of milk cows and young cattle.

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LONG-TERM FORECASTING OF AGRICULTURAL INDICATORS AND GHG EMISSIONS IN LATVIA

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***Abstract**. In Latvia, the agricultural sector contributes to approximately **20%** of the total national GHG emissions and is the **second largest** source of GHG emissions behind the energy sector (68%). In this context, it is of great importance to prepare necessary forecast data on the agricultural sector and to assess their credibility and effect on calculation results. Agriculture develops in a very changing environment; it is affected by climatic conditions, the market situation and technological progress. Forecasting in this sector is associated with specific problems; therefore, it has to be performed employing carefully prepared data and appropriate forecasting methods. The paper deals with long-term forecasting of agricultural indicators and GHG emissions in Latvia, which is based on a macroeconomic model and the use of a multifactor linear regression equation.*

Key words: *agricultural indicators, GHG emissions, long-term forecasting.*

INTRODUCTION

After regaining its independence, Latvia actively participates in the process of mitigating global climate change. The Parliament of the Republic of Latvia ratified the UN Framework Convention on Climate Change (hereinafter the Convention) [1],[2] in 1995 and the Kyoto Protocol of the Convention in 2002, which was a legal framework for Latvia's participation in mitigating climate change. In accordance with the Kyoto Protocol, Latvia had to achieve an 8% reduction in GHG emissions individually or together with other countries in the period 2008-2012, compared with the amount of GHG emissions in 1990. Latvia successfully achieved this target.

Even higher targets were set for the Kyoto Protocol's second commitment period until 2020 [3], which were adopted in 2012. In accordance with the second Kyoto Protocol, the European Union and thus its Member States have to reduce their emissions by 20% compared with 1990. To achieve this common goal in the EU, the commitments within both the ETC and the non-ETC sector have to be met. The non-ETC sector includes agriculture as well. The non-ETS commitments are imposed by the EP decision [3]. In Latvia, in accordance with the above-mentioned decision, the non-ETC sector's emissions may not exceed +17% compared with the 2005 data. The common EU-28 target is to achieve a 10% emission reduction in the non-ETC sector by 2020.

The Energy Policy Framework for 2030 [Climate and Energy Policy Framework for 2030] sets a number of objectives and tasks that all the EU Member States have to achieve until 2030 in order to mitigate the negative effects of climate change. The EC has set a target to reduce GHG emissions by 40% until 2030, compared with the level of 1990, in order to achieve a reduction of 80-95% until 2050 and to achieve the international objective of not letting the atmosphere warm up by 2 degrees Celsius [16].

Latvia's National Development Plan includes an objective to increase the proportion of the productively exploited agricultural area by reintegrating the abandoned and inefficiently used agricultural area into production. In order to increase agricultural production and achieve the set climate policy targets until 2030, Latvia has to seriously assess the measures needed for the reduction of emissions, although in this respect agriculture is characterised as a particularly "inelastic" industry. In making the urgent climate and air policies, it is stressed agriculture is an industry that is potentially emission-effective and has not used its emission potential until now.

Certain targets have been set for the non-ETS sector for each year after 2013; if the targets are not achieved, the way how to meet the commitments has to be found. In accordance with the UN Framework Convention on Climate Change, the Member States, including Latvia, have to submit an inventory of GHG emissions and their removal to the Conference of the parties (COP) every year.

Since 2011, in Latvia GHG emissions in the agricultural sector have tended to increase (Figure 1). In 2012, the total national GHG emissions equaled 10 978 Gg CO_2eq., the agricultural sector was the second largest source of GHG emissions (22%) behind the energy sector (65.8%) (*Latvia`s National Inventory Report 1990-2012*) [4]. GHG forecasts indicate that without extra measures, Latvia will not achieve its international GHG emission targets for the period 2013-2020 that have been set by decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 **o**n the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 [3]. For this reason, it is of great importance to make GHG forecasts for the agricultural sector, which are based on high-quality data on national activities [7],[8].

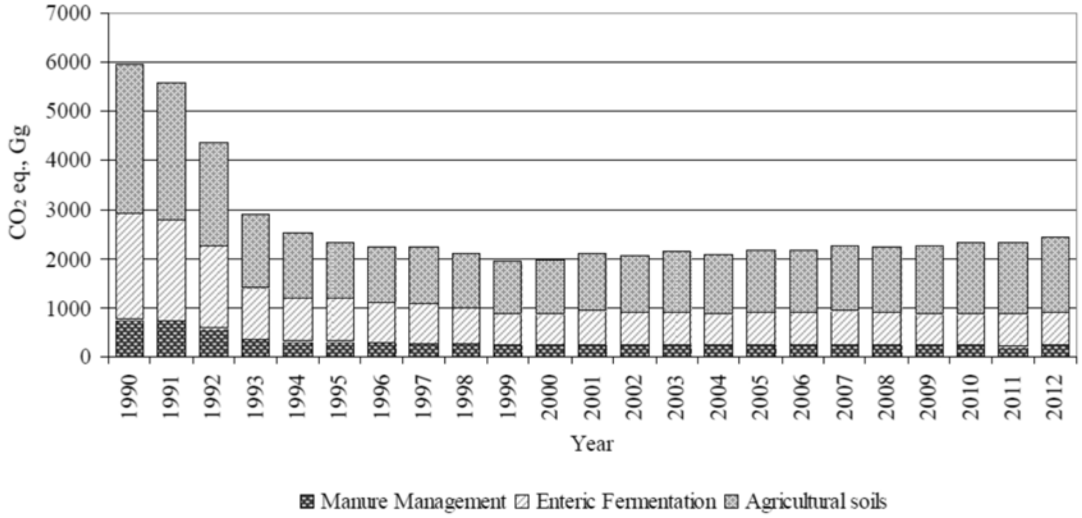

Figure 1. **Changes in GHG emissions in the agricultural sector [4]**

Making and reporting agricultural GHG forecasts in Latvia is carried out in accordance with the Convention on Climate Change and Regulation No 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change. The Regulation requires the Member States to report on their forecasts regarding greenhouse gas anthropogenic emissions to the EC and the secretariat of the Convention on Climate Change. The calculations of emissions are performed based on growth forecasts for various industries, which are also prepared for the agricultural sector for 2015, 2020, 2030 and 2050.

MATERIALS AND METHODS

Time series trend models are most often employed for the short- and long-term forecasting of agricultural indicators (up to 10 years). For instance, the following trend models were used to make forecasts for 2015 and 2020 in Latvia [7],[9],[10]: the linear trend model, the power trend model, the semi-logarithmic trend model, the exponential trend model and the polynomial trend model. The CAPRI system module CAPTRD also employs the power trend model in forecasting agricultural indicators [8].

Time series trend models are not suited for *long-term forecasting* (over 10 years), as the forecast period is too long. In this case, more complicated econometric or dynamic models are employed [13],[15].

In 2013, a correlative relationship between the GDP and the corresponding agricultural indicator was used for forecasting agricultural indicators for 2030 [7]. A GDP forecast for 2030 was produced by the Ministry of Economics (MoE) by employing a complex macro-model for Latvia's national economy [13],[14].

The present paper suggests using the MoE macro-model for the national economy and its forecasts to a greater extent and in more detail, i.e. indicators such as share of agriculture in GDP, number of population, agricultural exports, price of agricultural products and consumption of agricultural products have to be employed along with the GDP indicator. So, it is advised to employ a multifactor linear regression equation for forecasting agricultural indicators for 2030 [11].

RESULTS AND DISCUSSION

Summarising information on GHG emissions produced by a sector in Latvia and forecasting changes in the GHG emissions are necessary to be able to control compliance with the emission reduction targets and, if necessary, to take appropriate measures for reducing the level of emissions. This conception suggests using the MoE macro-model for the national economy and its forecasts to a greater extent and in more detail, i.e. indicators such as share of agriculture in GDP, number of population, agricultural exports, price of agricultural products and consumption of agricultural products have to be employed along with the GDP indicator.

So, it is advised to employ a multifactor linear regression equation for forecasting agricultural indicators for 2030 [11]:

$$\tilde{y}_{jt} = a_0 + a_1 x_{1t} + a_2 x_{2t} + a_3 x_{3t} + a_4 x_{4kt} + a_5 x_{5kt} + a_6 x_{6kt} \,, \tag{1}$$

where: $\tilde{y}_{ji}$ – j-th forecasted agricultural indicator (number of cattle, number of pigs, area sown with wheat, etc.) in the t-th year,

x_{1t} – GDP, bln EUR, in 2010 constant prices, in the t-th year,

x_{2t} – share of agriculture in GDP, %, in the t-th year,

x_{3t} – number of population, mln, in the t-th year,

x_{4kt} – price of the k-th agricultural product, thou EUR/t. (the price of beef, the price of pork, the grain price, the milk price, ect.) in the t-th year,

x_{5kt} – amount of exports of the k-th agricultural product, thou EUR, in the t-th year;

x_{6kt} – average consumption of the k-th agricultural product per household member per year, kg, in the t-th year.

Initially, the model includes all the six factors. If a factor with the smallest absolute value of the partial correlation coefficient is not statistically significant, the factor is excluded from the model. The exclusion is stopped if there are no more factors being statistically insignificant, i.e. their p-value is less than a=0.05.

The average confidence interval boundaries of the dependent variable are calculated according to the following equation [11]:

$$\Delta_{xid,x_t} = \pm t_{\alpha,\vartheta} \sqrt{s^2 \vec{x}_t^T \left(X^T \mathbf{X}\right)^{-1} \vec{x}_t} \,, \tag{2}$$

where: $t_{\alpha;\vartheta}$ – critical value of Student’s t-distribution;

a – tolerable probability of error of the forecast, a is assumed to be 0.1;

ϑ – number of degrees of freedom ϑ = n-k, n – number of observations, k – number of regression equation coefficients, k=5;

s_{yx} – regression standard deviation;

$$s_{yx} = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \tilde{y}_i)^2}{n-k}} \tag{3}$$

$$\vec{x}_t = \begin{bmatrix} 1 \\ x_{1,t} \\ x_{2,t} \\ x_{3,t} \\ \dots \\ x_{6,t} \end{bmatrix} \tag{4}$$

$$X = \begin{pmatrix} 1 & x_{1,1} & x_{2,1} & \dots & x_{6,1} \\ 1 & x_{1,2} & x_{2,2} & \dots & x_{6,2} \\ \dots & \dots & \dots & \dots & \dots \\ 1 & x_{1,24} & x_{2,24} & \dots & x_{6,24} \end{pmatrix} \tag{5}$$

If the multifactor linear regression model (1) is recorded in the form of matrixes:

$$Y = X * A \tag{6}$$

where:

$$A = \begin{pmatrix} a_0 \\ a_1 \\ \dots \\ a_6 \end{pmatrix} \qquad (7)$$

GDP forecasts, population number forecasts and forecasts of exports and private consumption will be based on the macroeconomic forecasts for Latvia for 2030 by the Ministry of Economics [1]. Forecasts on prices of agricultural products are based on a FAO research study [17].

Example of forecasting

Based on the forecasts for 2020 and 2030 by the Ministry of Economics of the Republic of Latvia, one can make the following forecast (see Figure 2.) by using formulas (1),…,(7):

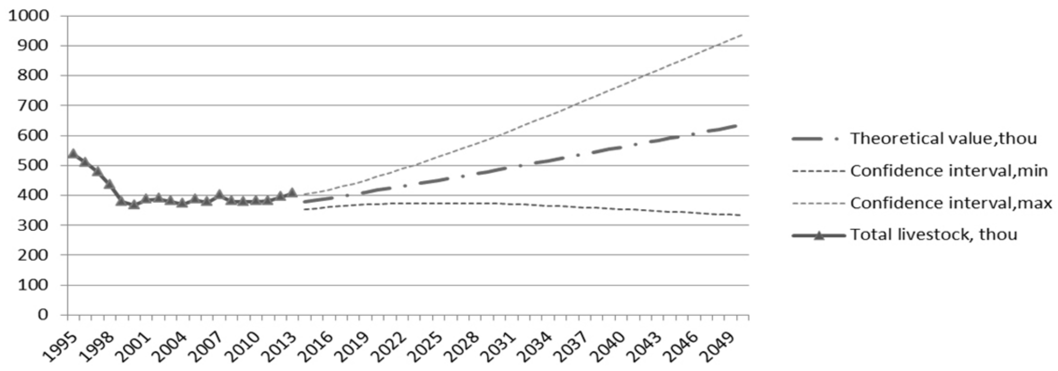

Figure 2. **Projections of changes in the number of livestock in Latvia till 2050**

After preparing the active data necessary for calculating GHG emissions by means of special models for forecasting emissions, based on the long-term macroeconomic forecasts, development strategies of and government policy documents for various industries produced by the Ministry of Economics, the calculation of GHG emissions is started. According to the forecast data on the development of the industry, the determination of GHG emissions is based on calculations in accordance with the guidelines developed by the Intergovernmental Panel on Climate Change (IPCC).

The IPCC guidelines for calculating GHG emissions set out methodologies of several levels: Tier 1, Tier 2 and Tier 3. Each next level means a more detailed and specific emission calculation methodology for every country as well as reduces the impreciseness of calculation results. The emission calculation methodology and the level are determined using decision-making trees. GHG emissions that may be characterised as the key emission source have to be mostly calculated according to the Tier 2 methodology. The methodology also specifies the recommended levels for calculating emissions from various sources, for example, the recommended levels for calculating methane emissions from intestinal fermentation processes are presented in Table 1.

Table 1

Methodology recommended for calculating methane emissions from intestinal fermentation processes [16]

Farm animal species	Recommended IPCC methodology level
Milch cows	Tier 2a/Tier 3
Other cattle	Tier 2a/Tier 3
Sheep	Tier 1/Tier 2
Goats	Tier 1
Horses	Tier 1
Pigs	Tier 1

Source: authors' construction based on the IPCC guidelines

The key factors determining emission calculation results are as follows:
1) active data for agricultural development (livestock and crop) indicators;
2) emission factor (EF).

For example, methane emissions from intestinal fermentation processes for each farm animal species are determined according to the equation:

$$Emission = EF(T) \cdot (N(T) / 10^6), \tag{8}$$

where: Emission = methane emission from intestinal fermentation processes, Gg CH_4 year^{-1};
EF(T) = EF for each farm animal species, kg CH_4 animal^{-1} year^{-1};
N(T) = number of animals of each farm species (T);
T = farm animal species.

Agricultural production active data may be divided into primary data for calculating direct emissions and secondary data for calculating the EF according to the Tier 2 methodology. Amounts of GHG emissions may be forecasted depending on the values of agricultural production intensity and the effects of the technology chosen (for instance, the use of a certain manure management system). In calculating emissions according to the Tier 1 methodology, standard emission factors are employed; therefore, the final result is closely associated with the active data used. In calculating emissions according to the Tier 2 methodology, the effects of various production technologies on the size of GHG emissions are taken into account, thus, the emission factor is calculated using country-specific values of agricultural production indicators. In this case, agricultural production indicator forecasts may be attributed not only to active data but also to assessments of the effects of production technologies. A final forecast result can be also affected by development plans for some specific agricultural industry, which can qualitatively correct a forecast produced mathematically.

CONSLUSIONS

1. The long-term forecasting of agricultural indicators has to be linked to macroeconomic forecasts for the country and to the development of the world market of agricultural products.

2. The multifactor linear regression equation whose factors are output macro-model indicators for Latvia – GDP, share of agriculture in GDP, number of population, agricultural exports, price of agricultural products and consumption of agricultural products – may be successfully used for the long-term forecasting of agricultural indicators.

3. Forecasting GHG emissions is based on the IPCC guidelines and forecasts of agricultural indicators. The overall result may be adjusted to the specific development plans of some agricultural industry.

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POSSIBILITIES TO REDUCE THE GREENHOUSE GAS CALCULATED EMISSIONS BY SPEEDING UP THE CALF AND KID DEVELOPMENT

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Abstract. *Ruminants emit more greenhouse gases than single-chamber stomach animals. Shortening the calf and kid fattening time and gaining a greater amount of high-quality dietary meat, can significantly reduce greenhouse gas emissions (GGE). Prebiotics can be one of the possible alternatives to prevent diseases, ensure good health and stimulate the growth of the animals. Studies have been conducted to find out the effect of the feeding of calves and kids with artichoke concentrate produced in Latvia containing the prebiotic – inulin (48.5-50.1%). The study was performed on two calves' (23±5 days old) and two kids' groups (14±5 day old) of animals: control group (n=8) and test (prebiotic) group (n=8). All the animals were fed equally, but in test group calves received additionally 12 g and kids 4 g of artichoke powder per day. Once a day general health was checked, including faecal mass consistency evaluation (Larson et al., 1977). After the planned slaughter (56th day of the study) carcass, rumen and abomasal weight measurements were made. We found out that the calves and kids of the test group had less diarrhea cases than control animals. In calves' control group the carcass weight was 43.57±8.16 and in test group it was 49.14±8.07, thus, on the 56th test day it was higher (p<0.05). Also kids' test group carcass was higher (p<0.05) than for the control animals (respectively 5.8±0.37 and 4.2±0.56). We concluded that the use of Jerusalem artichoke flour concentrate containing the prebiotic inulin when fed to the calves and kids generally gives positive impact on the development and growth of the animals, improves the functional status of the gastrointestinal tract and the morphometric indicators. Making more effective food intake and, possibly, also the digestibility, GGE could be reduced. The study was conducted by National research programs within AGROBIORES. Research is still continued.*

Key words: *calf, kid, development, inulin.*

MANURE MANAGEMENT SYSTEMS IMPACT ON GHG EMISSIONS

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Abstract. *Greenhouse gas (GHG) emissions from manure management consist of methane (CH_4) and nitrous oxide (N_2O) gases from anaerobic and aerobic manure decomposition processes. According to FAO, livestock contributes 37% of CH_4 emission and 65% of total N_2O emission [1]. Globally, livestock manure management accounts for almost 10% of GHG emissions from agriculture emissions measured in CO_2 equivalent [2]. Paper discusses GHG emission output by manure management practices in two most important livestock breeding sectors in Latvia.*

Key words: *manure management, emissions, greenhouse gas.*

INTRODUCTION

Livestock manure handling, storage and application practices have an important impact on the greenhouse gas (GHG) emissions from livestock operations in Latvia, contributing about 10% of total agriculture emissions [3]. Emissions of methane CH_4 and nitrous oxide N_2O from livestock production are regulated as part of the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC). Inventory of GHG emissions from livestock management account for several emission sources, including CH_4 emission from enteric fermentation and manure management; N_2O direct and indirect emission from manure management, as well as, manure applying to soils.

CH_4 emission from internal fermentation is affected by animal weight, feeding situation, milk yield and fat content, duration of the grazing period and other parameters, but most significantly by feed digestibility. High-quality feed can reduce this type of emissions by 15-20% and more.

CH_4 emissions from manure management are linked to manure characteristics, including volatile solids and the maximum amount of methane able to be produced. Calculation of these emissions is based also on manure management system characteristics and climatic conditions.

Direct N_2O emissions from manure management characterize emissions during handling, storing and treating of manure. Emissions of N_2O are strongly related to nitrogen amount excreted by animal.

Indirect N_2O emissions from manure management include nitrogen votalization in forms of ammonia (NH_3) and nitrogen oxides (NO_x). Indirect N_2O emissions may also form as a result of nitrogen leaching.

Direct emissions of N_2O from applying manure to soil depend on the amount of nitrogen in manure incorporated into the soil after storage. Incorporated bedding material increase total nitrogen content and consequently emissions.

Indirect emissions of N_2O from applied manure to soil estimates losses of nitrogen due to votalization of ammonia NH_3 and NO_x. Indirect N_2O emissions from applied manure to soil also include nitrogen leaching emissions. Impact of GHG emission output by manure management practices in dairy and pig production sector in Latvia are discussed in the paper.

MATERIALS AND METHODS

The methodology for estimating national CH_4 and N_2O emissions from livestock is based on emission factors devised by *The Intergovernmental Panel on Climate Change* (IPCC) guidelines [4].

RESULTS AND DISCUSSION

Dairy farming sector

Analysis of total emissions outcome for all manure management systems used in Latvia was done under the IPCC methodology. According to the results obtained by using 2006 IPCC guidelines, manure storing in open anaerobic lagoons shows highest amounts of GHG emissions, but the smallest amounts of emissions refer to utilizing manure for production of biogas (Fig.1). Emission analysis shows that high percentage of GHG emission amounts in the dairy sector is directed to CH_4 emission by internal fermentation, resulting in 60% of total emissions. The highest methane emissions from manure management relates to uncovered anaerobic lagoons. Particularly high methane emissions from internal fermentation are forming in the grazing period. It is influenced by the total energy required during grazing.

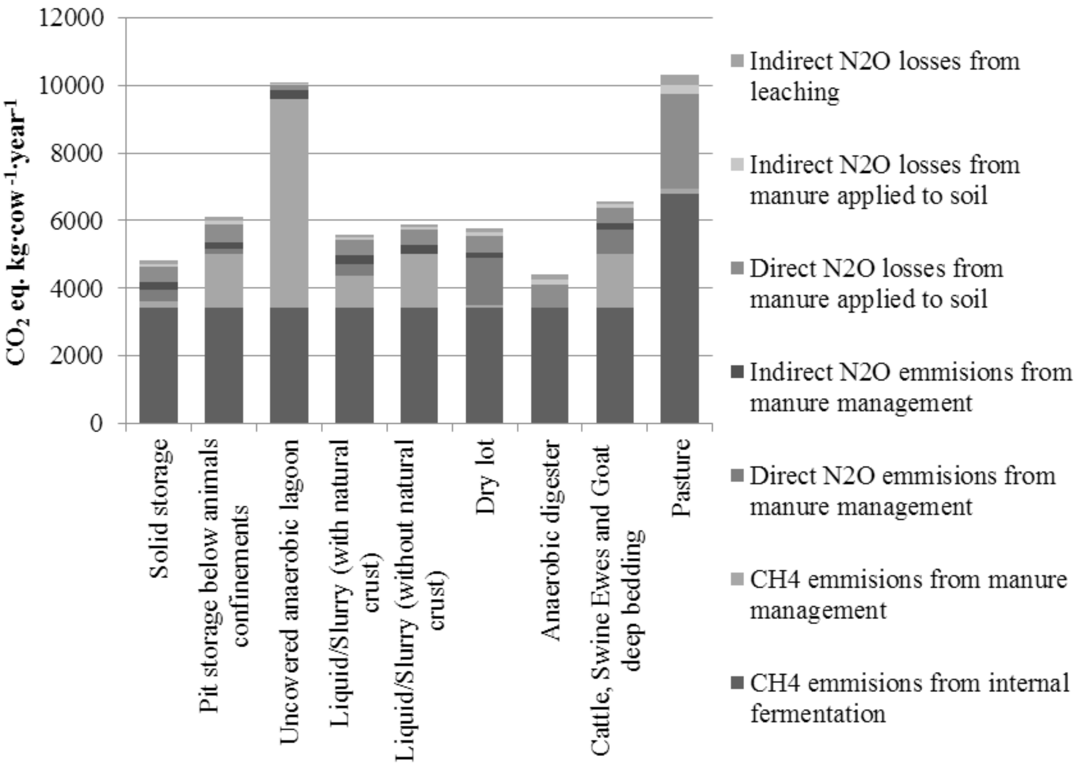

Figure 1. **Dairy sector GHG emissions from various manure management systems (60% digestibility)**

Different manure management systems are characteristic for dairy sector in Latvia, including solid, slurry based systems, anaerobic digester and pastures. Table 1 shows seven possible scenarios for manure management systems distribution.

Table 1

Scenarios of manure management systems distribution (MS), %

Manure management system	MS (1)	MS (2)	MS (3)	MS (4)	MS (5)	MS (6)	MS (7)
Slurry	20.3	28.3	34.0	44.0	50.0	60.0	70.0
Solid	55.0	50.3	48.3	41.9	40.0	34.2	28.2
Pastures	24.7	20.5	16.4	12.3	8.2	4.0	0.0
Anaerobic digester	0.0	0.9	1.3	1.8	1.8	1.8	1.8

In last year's, dairy farming turn to liquid slurry management system, however liquid slurry produces more methane and promote increase of this kind of emissions. Emphasis on enlargement of the share of slurry based manure management systems consequently increases CH_4 emission during handling and storage period (Fig.2).

Swine Production Sector

Analysis of GHG emissions in the swine production sector at different manure management systems shows that the majority of emissions from a swine refer to manure management emissions. The lowest level of emissions results from the use of manure for biogas production (Fig. 3). Methane emissions from manure management process may be evaluated as 20-90% of the total GHG emissions.

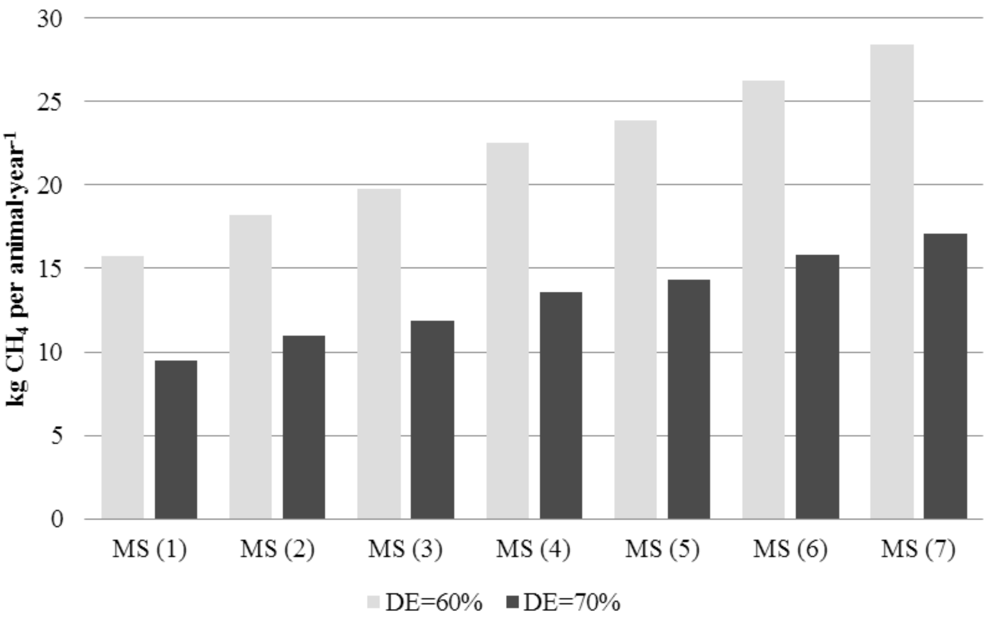

Figure 2. **CH_4 emission amounts under different scenarios of manure management system development**

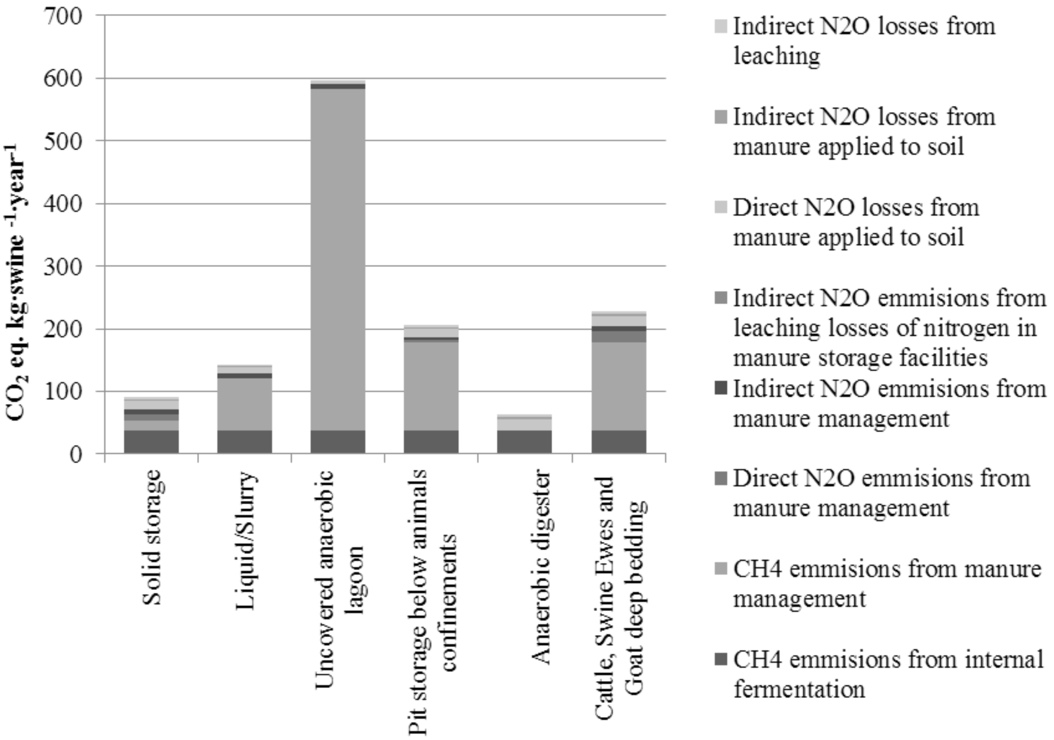

Figure 3. **Swine production GHG emissions from various manure management systems**

CONCLUSIONS

GHG emissions analysis in the dairy farming sector shows that the most important part of total emissions resulting from internal fermentation, which can be reduced by improving the feed quality and digestibility.

GHG emission reduction possibilities in swine production branch should be focused on manure management systems.

Highest emissions result from uncovered anaerobic lagoons, the smallest if manure is utilized for production of biogas.

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EFFECT OF ORGANIC FARMING ON CLIMATE CHANGE

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Abstract. *Organic farming has multiple objectives and potential gains, for example, biological diversity, provision of soil quality and animal welfare, avoidance of pesticides and justice in the entire production chain. However, with regard to reducing greenhouse gas (GHG) emissions, this production pathway not always makes a positive contribution; for this reason, a solution is required regarding how to calculate the amount of emissions in organic farming and what opportunities may be regarded as improvements. Maintaining soil fertility though crop rotation, using green manure and livestock manure and reduced soil tillage are the direct techniques for reducing the consumption of energy resources and a more efficient use thereof. However, organic farming provides additional gains; for example, it contributes to the preservation of biological diversity and to animal welfare, supplies local products of natural origin, protects the environment from pollution with chemicals and, in general, ensures sustainable agricultural management.*

Key words: *organic farming, climate change, soil fertility, reduced soil tillage.*

INTRODUCTION

The organic farming movement in the European Union increasingly introduces innovative techniques in agricultural production, which is a good foundation for successful agricultural management and which also reduces greenhouse gas emissions. IFOAM EU Work Programme 2015 notes that organic farming is more stable and sustainable and it can significantly contribute to reducing greenhouse gas emissions in the agricultural industry and promote adaptation to climate change; besides, it is ready to increase its capability to support more ambitious actions aimed at reducing agricultural greenhouse gas emissions at EU and national level. Organic agriculture provides management practices that can help farmers adapt to climate change through strengthening agro-ecosystems, diversifying crop and livestock production and building farmers' knowledge base to best prevent and confront changes in climate. Organic farming practices are positioned in SBSTA's (Subsidiary Body for Scientific and Technological Advice) work as key solutions for mitigation and adaptation of agriculture, improving food and nutrition security and livelihoods of farming communities worldwide. IFOAM EU supports a more effective reduction of GHG emissions within the EU Climate Package 2030 in the whole agricultural sector, including organic farming [2].

CARBON SEQUESTRATION IN SOIL AND ITS ROLE IN REDUCING CLIMATE CHANGE

An annual research study by Rodale Institute in the USA, comparing the organic and conventional agricultural systems, proved that equal yields can be achieved in a long-term if necessary conditions are ensured in both systems. In the organic agricultural system, higher yields are achieved in dry years, as this system contributes to the formation rather than the depletion of organic matter in soil, thus making the system more sustainable. Rodale Institute scientists have calculated that organic farming consumes 45% less energy and the energy is used more efficiently, while the conventional agricultural system produces 40% more greenhouse gases; this system turned to be economically more efficient than the conventional one [7].

However, a 21-year research study (DOK-Trial) by the Research Institute of Organic Agriculture (FiBL) in Switzerland showed that crop yields in organic farming were approximately 20% lower than those in conventional farming that used fertilisers; at the same time, the amount of nitrogen brought into the organic and the biodynamic system was 65%, phosphorous 40% and potassium 45% less. In a long-term, the account of nutritional elements brought in/out showed that all the researched systems received less nitrogen than it was necessary for crops (the additional nitrogen withdrawn was derived from soil mineralisation, nitrogen fixation by leguminous plants, and aerial deposition). The deficit of phosphorus and potassium in the organic system was even greater; therefore it is important to regularly determine the amounts of nutritional elements in soil and the biogenic reserves available for crops.

Like in the research study by Rodale Institute, Swiss scientists have also calculated that the production of organic crops requires 30-50% less energy per area unit than in conventional production (for the production of energy, fertilisers and pesticides). Although the yield per area unit in the conventional system is higher, energy consumption per unit in the organic system is 19% lower [11].

The lack of mineral elements is one of the key distinctions between the organic and the conventional management system; accordingly, a much greater role is played by green manure from crop rotation, especially stressing the availability of nitrogen for crops. A more appropriate organic management model involves mixed crop-livestock farms where the source of nitrogen is manure. However, in this respect, it is important to assess the effects on the environment, as the density of animals and the amount of manure produced are interrelated variables [3]. The greatest emission reduction potential in agriculture relates to carbon sequestration in soil where the greatest role is played by organic farming, which, in this respect, may be placed on the same level with growing leguminous crops and using manure. Yet, it is important to optimise the soil fertility maintenance system, assessing the link between the rotation of crops, the type of soil, fertilisation and carbon sequestration in soil. Optimisation in the livestock industry requires a global vision, accounting for life-cycle emissions of feed production. By feeding coarse fodder, emissions decrease; yet, the most effective way is to radically reduce the number of livestock, which is possible in the organic system, as the density of animals in such farms is lower. This aspect has to be taken into consideration beyond the agricultural industry, changing the food consumption habits in the society, for example, the consumption of meat has to be reduced or attitude to food waste has to be changed. Organic farming is well positioned as a way of mitigating climate change in a systemic context; therefore, if seeking for ways how to mitigate climate change, change in attitude is also needed in conventional agriculture. One has to understand the significant role of carbon sequestration in soil, and one has to focus on a global approach to sustainable systemic and multifunctional agriculture [5]. Financial assistance for transition from the conventional to the organic system or for introduction of climate-friendly practices on crop and livestock farms could be an important step towards agricultural sustainability; besides, organic farming makes a significant contribution to the production of products of plant and animal origin:

- in the process of production of crop products, composts are used, biological waste and manure are stored and used for soil fertilisation, biogas is produced and the burning of biomass is avoided in agroforestry to maintain the balance of carbon in soil. Given the fact that the agricultural area is large, carbon sequestration in soil has a large potential to mitigate global climate change;
- the key focus in the production of livestock products is placed on the reduction of greenhouse gas emissions per unit of product produced. The reduction of use of feed concentrates has a large potential, as the use of land, to a great extent, affects the production of feed concentrates. It is difficult to determine a direct gain from carbon sequestration, but additional gains are important, for example, energy efficiency, biodiversity, a greater amount of organic matter in soil, higher soil fertility and the whole system's stability and endurance in a long-term [6].

APPLICATION OF REDUCED SOIL TILLAGE

One of the most effective ways of reducing GHG emissions is to minimise soil tillage, thus decreasing the consumption of energy resources. Using such a technique in the organic management system can lead to lower crop yields; yet, research studies show that a decrease in yields not always correlates with the intensity of soil tillage, but usually yields decrease if the intensity of soil tillage is reduced. Reduced soil tillage affects the yields of leguminous crops to a smaller extent and the rotation of crops also does not influence the differentiation of yields. An increase in weediness is a greater risk, which can make a greater contribution to lower yields.

Organic farming has to provide ecosystem services of conservation agriculture, while at the same time maintaining crop yields consistent with all optimal agricultural and technological activities (crop rotations, crop choice and tillage intensity). Deep soil tillage has to be performed in the beginning of crop rotations when weeds have to be intensively controlled, green manure has to be incorporated into soil or permanent grasses have to be restored. Yet, it has to be taken into account that deep ploughing can cause immediate loss of accumulated soil organic carbon and that large pores built by earthworms and roots may be disrupted. It is useful to employ a double-layer plough for primary tillage or some other specific tool, for example, chisels with large goose feet sweeps or a stubble cleaner to undercut the soil and thereby control weeds, and special ploughs to superficially till the soils may still be useful. However, traditional tools can be also used in minimal soil tillage [1]. No-till or minimal soil tillage techniques have to be employed as conserving soil tillage techniques with high potential to restore or improve the functions of soil and significantly mitigate climate change. Yet, in the temperate climate zone, the use of green manure and minimal tillage, which positively affects soil qualitative characteristics, for example, the amount of carbon in soil, the biomass of microorganisms in soil and fermentation in the upper layer of soil, are the most appropriate. However, according to research studies, the positive effects of crop rotations on microorganism communities, bacteria, fungi and earthworms are stronger than soil tillage effects. The introduction of crop rotations and minimal tillage reduces carbon emissions and labour consumption. It is suggested that reduced soil tillage in organic farming can contribute to a more flexible crop system in the future [4].

EMISSION REDUCTION OPPORTUNITIES

According to a number of researchers, nitrous oxide emissions from organically managed soils are 492 ± 160 kg CO_2 eq. $ha^{-1}a^{-1}$ smaller than from non-organically ones. The difference in emissions from arable land reaches 497 ± 162 kg CO_2 eq. $ha^{-1}a^{-1}$. However, if measured per unit of crop yield, nitrous oxide emissions are greater by 41 ± 34 kg CO_2 eq. $ha^{-1}a^{-1}$ DM. To equalise the difference in nitrogen oxide emissions between both types of farming, the difference in yields has to be less than 17%. In the conventional system, nitrous oxide emissions mostly arise from the use of nitrogen fertilisers, whereas in the organic system, in this respect, soil properties are more important. It may be explained by faster availability of non-organic fertilisers, whereas in the organic system N mineralisation takes place at a much slower pace [9]. In the conventional system, nitrification inhibitors, which reduce the activity of soil bacteria and thus hinder the process of denitrification, are an effective means for mitigating environmental problems and improving the use of nitrogen. An inhibitor is added to the fertilisation product that contains ammonia and carbamide in order to increase the effectiveness of use of N fertilisers, reducing nitrogen leaching and emissions [10]. In the organic system too, using liquid manure, it is possible to add an inhibitor for the purpose of increasing the absorption of N from slurry, reduce its leaching loss and N_2O and NO emissions, especially if fertilising grassland [8].

CONCLUSIONS

By optimising the soil fertility maintenance system, assessing the link between the rotation of crops, the type of soil, fertilisation and soil carbon sequestration in the organic farming system, it is possible to reduce GHG emissions.

The introduction of green manure in combination with a minimal soil tillage system reduces GHG emissions from organic farming.

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FOOD QUALITY AND SAFETY

LOW TOTAL BACTERIAL COUNT IN BULK MILK WITH AMS

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Abstract. *Using an AMS (Automatic Milking System) to obtain a good milk quality with low total bacterial count (TBC) in the bulk milk can be a challenge, but is manageable. A pre-survey within the AMS farms in Iceland, which had the lowest TBC in the bulk milk, showed that there are many similarities with the work routine of the farmers getting the best results. At all farms the system wash was done three times daily and all farms used pre-cooling systems. All farmers had focus on the cleanness of the robot, the AMS box and the floor around the box. Furthermore all farms had some kind of automatic system to scrape the main floors and walking alleys for the cows. The five lowest AMS farms had in common that in all of them the cubicles was scraped down at least three times daily and a fresh bedding material was put op into the cubicles twice daily. All farmers at those AMS farms with low TBC in the bulk milk also kept their cows clean by all above handlings plus getting the udder and tail hairs trimmed at or before calving.*

Key words: *TBC, Milk Quality, Automatic Milking.*

INTRODUCTION

Using an AMS (Automatic Milking System) to obtain a good milk quality with low total bacterial count (TBC) in the bulk milk can be a challenge but is manageable. In Iceland the milk from AMS, which accounts for about 30% of all the milk produced in the country, is of lower quality than from conventional dairy farms; however there is a big difference in milk quality within the AMS farms and some are producing milk on the same levels as the best conventional farms.
In a pre-survey within the AMS farms in Iceland, that had the lowest TBC in the bulk milk, showed that there are many similarities with the work routine of the farmers getting the best results.

MATERIALS AND METHODS

The average direct bacterial count was for all 665 dairy farms in Iceland (in 2010) was 29.400 CFU/mL. However the average bacterial count for the 95 AMS dairy farms was 52.400 CFU/mL compared to 25.600 CFU/mL for the 570 conventional dairy farms. The five lowest AMS dairy farms had, however 17.300 CFU/mL in average in bacterial count. The dairy farmers, running these five AMS farms, where interviewed about their management practice to establish a basis for recommendations to other AMS dairy farmers in Iceland and for the purpose of further research within the topic.

RESULTS AND CONCLUSION

The result showed that at all farms the AMS systems was set to make a full system wash three times daily and all farms used a pre cooling water system, when pumping the milk to the bulk tank. All farmers followed the manufacturer's recommendations for changing parts and had also a fixed routine for checking status on cleaning agents. The farms with Lely also disinfected and changed the cleaning brushes at least once to twice monthly. Two out of those five farmers just changed the milking filter once daily.
When asked about other work the farmers had in common that they all keep a good eye on the cleanness of the robot, the robot arm and the environment around the AMS box on both sides. All washed the box floor, the slotted floor close to the box and the robot arm at least 3 times daily and the AMS box at least twice daily.
In all dairy barns there where automatic systems used to scrape the main floors and walking alleys for the cows: farms with slotted floors to be cleaned every two hours and farms with solid floors every hour. All farmers also had their focus on manually scraping at least twice daily the alleys that automatic systems could not get to. Furthermore the process of scraping manure from the cubicles was done at least three

times daily in all farms and at least twice daily the cubicles were bedded with new bedding material, usually sawdust.
The cows was kept clean by all above handlings plus getting the udder and tail hairs trimmed at or before calving.

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FOOD CO-STREAMS FOR INNOVATIVE FOOD AND FEED PRODUCTS

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Abstract. *The CYCLE project aims at reducing food loss by creating innovative food and feed products and ingredients, in a close cooperation with the Norwegian food industry. Three important food chains are involved: chicken, white and pelagic fish, and vegetables and potatoes. Bioforsk, VTT and SINTEF cooperate on hydrolisation of chicken co-streams to produce oil and proteins, and to develop healthy food products as well as products with a specialised function from vegetable and potato co-streams. Experience from seafood at SINTEF is brought in contact with food and feed knowledge in Bioforsk and VTT, and a close contact with food industry ensures a high relevance for developed processes and products. The paper presents preliminary results in the development of oil from chicken bones, proteins from chicken feathers, vegetable smoothies and suberin films made from potato peels, as example of food and feed innovations based in bioeconomy.*

Key words: *chicken, CYCLE project, food industry co-streams, protein hydrolysis, vegetables.*

INTRODUCTION

The research project "Total utilisation of raw materials in the supply chain for food with a bio-economical perspective" (CYCLE) aims at improving the resource utilisation in the Norwegian food industry by developing eco-friendly bio-processes, applying novel technology. The project (2013-2017) involves research institutes from Norway, Finland and Denmark, with social scientists, food technologists and agronomists cooperating closely with industry partners. CYCLE aims at finding new ways to utilise co-streams generated during the processing of food raw materials, and thereby reducing food loss. We develop technologies to transform co-streams to innovative products with a high economic value. The project is funded by the Research Council of Norway with totally 5 million €, and included in the program "Sustainable Innovation in Food and Bio-based Industries" (BIONAER). The project studies three central food chains in Norway: Vegetables and potatoes; white and pelagic fish; and chicken.

Efficient utilisation of raw materials in the food sector generally implies that a high proportion is processed to food and feed. According to the waste management hierarchy of the EU [1], avoiding waste generation is the main strategy, followed by re-use, recycling, recovery and disposal of waste. Waste is defined as any substance or object which the holder discards, or intends to discard, or is required to discard [1]. For the food processing industry, utilisation of co-streams for feed or technical applications often gives a lower rate of return than for food applications, or may even be a net cost. However, this net cost may be lower than disposal would cost. With high energy prices and economic support for renewable energy, as found in some European countries like Denmark and Germany, energy production from co-streams by digestion or incineration may be profitable enough to allow for a payment to the industry. In Norway, energy prices are generally low due to the large availability of hydroelectric power. The industry has to pay a fee for waste disposed as landfill or incinerated for destruction by methods which do not include utilisation of the energy. For waste incinerated for energy production, there is no end-treatment fee since October 1, 2010 [2], but local incineration plants may charge a fee for disposal of high-risk animal co-streams. The Norwegian waste classification system comprises the categories recycling, biological treatment (i.e. composting, anaerobic digestion), filling and covering compounds (e.g. for road construction), incineration for energy production, incineration without energy production (i.e. destruction), and landfill.

The term food loss is used to describe a decrease in edible food mass within part of a food supply chain that leads to edible food for human consumption [3]. Food losses occur throughout the entire food chain, from primary production via postharvest handling and storage, to food processing, distribution, retailing and consumption. Globally, annual food losses are estimated to account for about 1,300 million tonnes, about one third of the total food produced for human consumption [3]. In the Nordic countries, food losses are largest in primary production and households, but losses from the food processing are also significant [4]. In total, 335 to 460 thousand tonnes of food, 62 to 86 kg per capita, are lost annually in Finland by consumers, retailers, food services and food industry [5]. When food is utilised for non-food purposes, we may distinguish between planned and unplanned non-food use. Utilisation for feed, fertiliser or bioenergy production may be a planned non-food use, whereas ploughing down a non-harvested crop may be an unplanned non-food use [3]. Still, both non-food utilisations are included in the food loss. The term food waste is used to describe food losses occurring at retailers and consumers, in the end of the food chain. The terms food loss and food waste only refer to products that are directed to human consumption, and are not used to describe a decrease in the amounts of materials integrated in the raw materials, such as fish skin or potato peel. The term "waste" does not necessarily refer to the inherent qualities of a co-stream, but is rather a subjective term, as a material may be waste for one user and a resource for another. Therefore, we avoid the term waste in the CYCLE project. Instead, we use the term co-streams to describe all food-processing by-products [6].

Two co-streams from the poultry industry that could well be more efficiently utilised, are minced residues after mechanically deboning of meat (MDM), and feathers. The current utilisation is as feed for fur animals and ingredients in pet food. Both co-streams are rich in protein, and MDM residues also contain high amounts of oil and minerals. The main component of feathers, beta-keratin (95% of dry weight) has a very low digestibility since beta-keratin is resistant to degradation due to disulphide bonds. Keratin can be solubilised by high-pressure boiling, chemical hydrolysis, enzymatic hydrolysis, microbial fermentation or by combinations of these treatments. Globally, 24 billion poultry birds are produced each year. Assuming an average body weight of 2 kg and a feather content of 5%, the total amount of feathers produced is 2.4 million tonnes per year. In spite of this huge amount, only few companies produce feather meal in Europe, applying the standard method of pressure boiling to produce about 175.000 tonnes of feather meal annually. In Europe, feather meal may only be utilised as feed for pets, fish and fur animals, and as a fertiliser. Typically, feather meal has 70-80% crude protein with a digestibility of 60-70%. Prices vary between 250 and 550 € per ton. Research on alternative methods to pressure boiling has shown a potential to improve the digestibility and amino acid composition of feather meal, and at the same time decreasing production costs. However, these revised methods have not yet been adapted to industrial scale, likely related to knowledge gaps and costs. In CYCLE, we aim at developing production methods for feather meal with higher digestibility compared to the standard method. In this paper, we will discuss some observations from an initial experiment to study effects of pressure boiling combined with commercial enzymes on the digestibility of non-solubilised feather keratin. We also present initial results of enzymatic hydrolysis of chicken bones [7], which has been a research topic at SINTEF for some years and is now further studied in CYCLE.

From the vegetable industry, second-class products and peelings constitute co-streams that are currently utilised for starch and alcohol production (potatoes), as animal feed or digested for biogas. Sludge (with peels) after washing is disposed as landfill. For such products used as animal feed, the short shelf life poses a problem. Second-class products and leftovers from production e.g. of ready-to-eat, cut lettuce are usually food products of high quality, and people are encouraged by health authorities to eat more vegetables. This calls for innovative utilisation of the vegetable industry co-streams, and in CYCLE we have tested vegetable smoothies. Initial results are presented here. Some co-streams, e.g. potato peels with a high content of suberin, may also possess characteristics that can be utilised in special applications. Suberin is a waxy compound, which forms a protective layer in potato peel cell walls. We present characteristics of a suberin film produced in the CYCLE project.

In summary, this paper presents initial results of some CYCLE studies where food co-streams are utilised for innovative food products and animal feed components. The studies are still in an early stage; however, when linked together, they comprise an interesting example of how cooperation between food and feed science and industry inspires research in the era of bioeconomy.

MATERIALS AND METHODS

Chicken feathers for protein feed (Bioforsk, SINTEF, VTT)

Autoclaved dry chicken feathers (7 g, delivered by Norilia, Norway) were cut by scissors and subjected to five hydrolysis treatments with untreated feathers as a control. The treatments compared were pressure boiling, two commercial keratinolytic enzymes, Protex 30L (Genencor International, Inc., Rochester, NY) and Cibenza IDN900 (Novus International, Inc., St. Charles, MO), Cibenza combined with subsequent pressure boiling, and one alkali treatment (Table 1). All treatments were replicated twice. After the hydrolysis step, nitrogen (N) solubility was measured by filtration and analysis of Kjeldahl-N in the residues. Ground residues were subjected to *in vitro* pepsin digestion (0.2%) and residues were separated by centrifugation and analysed for Kjeldahl-N. N-solubility and *in vitro* N-digestibility were calculated as the proportion of N in the solution divided by total N. Casein was used as a reference for digestibility analysis.

Chicken bones for edible oil (SINTEF)

After processing chicken parts to produce deboned meat, bones, cartilages and a small proportion of meat comprises a valuable co-stream for production of oil and protein. Minced material (1500 g) was mixed with water (1500 g, 50°C) and heated to 50°C in a 4000 ml reactor. The enzymatic hydrolysis was started by adding 0.1% of commercial enzyme (dry weight enzyme/raw material) of either Protamex, Corolase PP, or a mixture of Papain and Bromelain. Samples were taken from the reactor after 0, 30, 60 and 120 minutes and inactivated by immediately heating (5 minutes, 90°C). The samples were divided into 50 ml tubes, and centrifuged for 10 minutes. The samples were further separated into four fractions; oil, emulsion, chicken protein hydrolysate and sediments.

Vegetable residues for smoothies (Bioforsk, VTT)

Aiming at utilising vegetable co-streams as innovative food products, we tested carrot, lettuce, Swedish turnip, red beets and spinach as raw materials for production of smoothies. To optimise colour, three groups of coloured smothies were selected: green leafy smoothie, orange carrot based smoothie and red red-beet based smoothie. We aimed for raw extracts to be consumed fresh or fermented, possibly combining vegetable extracts by fruit extracts in the final smoothies. Mixtures Carrot 1, 2, 3 and Lettuce 1, 2 were evaluated by a local consumer panel. In the carrot mixtures, boiled carrots were mixed with water (Carrot 1), raw carrot juice (Carrot 2) or apple juice (Carrot 3). Leaves of Iceberg lettuce was mixed with apple juice (Lettuce 1), or baby leaf leaves were added to this mixture (Lettuce 2). In a second step, leaves of Iceberg lettuce was mixed with Swedish turnip (Lettuce 3), and to this mixture red beet juice was added (Lettuce 4) to improve colour and sugar content. The final mixture tested in the second step contained boiled red beets, red beet juice and Swedish turnip (Red beet). In the second step, only five persons participated as respondents. In a third step, we tested whether the attractiveness of the smoothies could be increased by adding fruity ingredients. One green mixture (Green fruit) of leafy vegetables and melon (6% spinach, 25% lettuce, 35% *piel de sapo* melon, 20% apple juice, 4% kiwi, 10% water) and one orange mixture (Orange fruit) of carrot and mango (35% boiled carrots, 25% mango, 12% water melon, 15% apple juice, 13% water) was tested.

In all mixtures, root vegetables were used after boiling, or juiced and filtrated to remove fibres. The combined ingredients for each mixture were homogenized by blending (Colin ® 34-6583, type BL1616) for 1 minute. Sugar content was measured by refractometer (Brix) and acidity by pH measurements. Viscosity was measured on the prepared smoothie mixtures by a rotation viscometer (Visco tester VT 01/02, Gebryder Haake, Belin, Germany). The extracts will be exposed to fermentation in the next step of this study. Hence, we composed extracts with sugar content > 5% and acidity > pH 5. Extracts that fulfilled these requirements were tested in a sensory preference test by a local consumer panel at Bioforsk with the following alternatives for classification: dislike very much (1), dislike (2), neither like nor dislike (3), like (4) or like very much (5). The panel comprised 11 persons except for one extracts with raw carrot juice (one person being allergic). The test persons were asked to give additional comments to their classification of each sample. A similar test was performed for the vegetable smoothies with fruit supplements, which were tested at a seminar for food scientists in Potsdam, Germany in October 2014 ("Best of the Rest"-seminar), with 23 persons commenting the Green and 22 persons the Orange mixture.

Potato peels for edible film (VTT)

By industrial potato peeling, up to half of the raw material potatoes may end up into peels, which are used as feed. Peels are rich in starch and they contain also suberin. Both starch and suberin could serve as components in edible films. We aimed at evaluating film forming properties of a suberin-enriched potato peel fraction and potato peel mass as such, and to compare their properties with a film prepared from pure potato flour. Industrially carborundum peeled Nicola peels were used as raw material. The material was stored as frozen, and before film preparation thawed and wet-milled in a Masuko grinder at 10% solids content using 0.25 mm and 0.2 mm gaps. Potato-based fractions used to prepare the films were:

- Suberin-enriched peel fraction (0% starch) obtained after starch was gelatinized by heating, hydrolysed with amylase enzymes and removed by filtration.
- Peel mass as such (46% dry matter (DM) starch)
- Potato flour (100% DM starch, Finnamyl)

Dispersions were prepared of potato fractions by high-pressure homogenization at 2% consistency in a Microfluidics fluidizer M-110EH-30 (4 passes). The operating pressure was 1500 bar. In the film preparation stage, glycerol, which was used as plasticizer, was added at 20% concentration of potato dry weight. The solutions were mixed with SpeedMixer for 5 min, at 1600 rpm under 100% vacuum, cast onto Petri-dishes and dried for two days at ambient conditions. Thickness of the dried films varied between 60 and 90 µm. Rates of water vapor and oxygen transmission as well grease penetration and mechanical properties of the films were determined using standard methods.

RESULTS AND DISCUSSION

Feather protein

Hydrolysis with NaOH gave the highest N solubility, but *in vitro* digestibility for that treatment could not be analysed due to clogging in the filter paper and low amount of residues. Enzymatic hydrolysis with subsequent pressure boiling resulted in much lower solubility, but the digestibility of the residue was higher than for pressure boiling alone. Enzymatic treatment alone improved solubility slightly, but had no effect on digestibility. A possible interaction between pressure boiling and enzymatic treatment could not be studied in this initial experiment, but is worth further studies. More research is needed to explore possible interactions between enzymatic treatments and pressure boiling. Furthermore, differences in digestibility and amino acid composition of solubilised keratin and residues may be studied in new experiments.

Table 1

Solubility and *in vitro* pepsin digestibility of N in hydrolysed chicken feathers (n = 2). SD= standard deviation; NA not analysed.

Treatment	Specification	N solubility (SD)	N digestibility of residue (SD)
Pressure boiling	125°C ×2 h ×2.4 bar	9% (0.0)	41% (2.0)
Protex 30L	50°C ×2 h + 80°C ×1 h	7% (0.2)	11% (0.2)
Cibenza IDN900	50°C ×2 h + 80°C ×1 h	13% (0.5)	2% (3.6)
Cibenza IDN900 + pressure boiling	50°C ×2 h + 125°C ×20 min×2.4 bar	19% (0.3)	62% (9.2)
NaOH (1 %)	50°C ×2 h + 80°C ×1 h	91% (0.8)	NA
Untreated feathers	20°C ×3 h	1% (0.1)	20% (0.4)
Lab-grade casein	-	-	87% (1.1)

Chicken oil

The minced chicken bones (+ cartilage and some meat) consisted of 15.8 ± 0.6% protein, 17.5 ± 2.0% lipids, 5.8 ± 1.9% ash, and 37.7 ± 2.2% water. The oil yields after enzymatic hydrolysis was independent of enzyme type and hydrolysis time ranging from 10.4 ± 0.8 to 12.2 ± 0.1 g oil per 100 g raw material. After 60 minutes of hydrolysis recovery values ranging from 62.2% (Corolase PP) to 71.2% (mixture of Papain and Bromelain) was obtained compared to the total oil content in the rest raw material. The lipid class distribution of the oil fraction was found to consist of mainly triacylglycerol (TAG, 99.1-99.7%), whereas only traces of free fatty acids (FFA), cholesterol (CHL) and phospholipids (PL) were detected. The main component in the oil fraction was the monounsaturated fatty acids (MUFAs), which made up more than 45% of the total amount of fatty acids in the oil. The amount of FFA found in the oil produced by enzymatic hydrolysis was below 0.3%, indicating a high quality raw material. The oxidation status and oxidative stability of the oils will be evaluated.

Vegetable smoothie

Scores of all tested mixtures are shown in Figure 1. Among the Carrot mixtures, there was a clear preference for Carrot 3, with 60% boiled carrots and 40% apple juice. Lettuce 1 was about as popular as Carrot 1. Lettuce 1 (Iceberg lettuce and apple juice) was characterised as fresh, but had a distinct bitter taste from the iceberg lettuce. Lettuce 2, with baby leaves added, was the least popular. It was characterised as having too much grass taste and being too bitter. When including more vegetable species, Iceberg lettuce mixed with Swedish turnip produced the most popular mixture, Lettuce 3. The turnip supplement caused a surprising, fresh and strong taste which balanced the bitter taste of iceberg lettuce. Addition of red beet juice (Lettuce 4) changed the light green colour extract to a pleasant, purple red colour, and improved sugar content. Boiled and juiced red beet with turnip (Red beet) was not very popular. When including fruits such as melon (Green fruit) and mango (Orange fruit), we found that both mixtures were quite popular (Figure 1), and the orange mixture scored best. For the first time, the highest score (Like very much) was used by some respondents. For the fruity mixtures, the scores dropped drastically when the smoothie temperature increased during serving. 13 answers recorded towards the end of the test when extracts were closer to room temperature had much lower scores than the values shown for the first 22 (23) respondents in Figure 1.

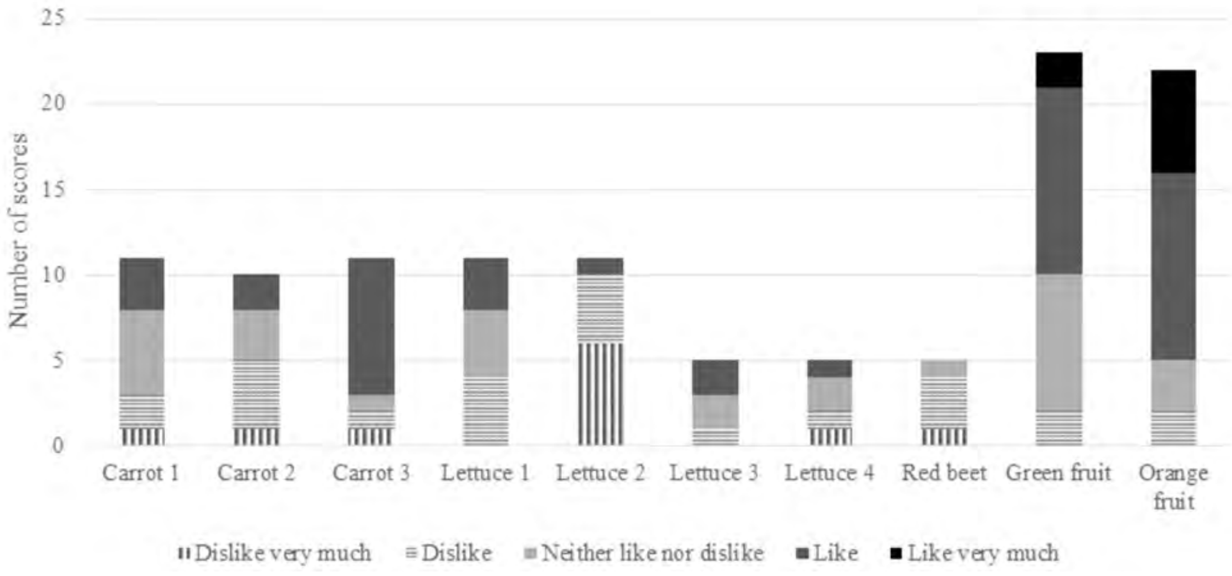

Figure 1. **Number of scores in a preference test of vegetable mixtures**

Further studies on vegetable smoothie will include effects of fermentation on taste, concentrations of healthy compounds such as vitamins and physical characteristics like stability and shelf-life. Interesting strains of fungi and bacteria have been developed at VTT, and will be tested with promising mixtures.

Edible film from potato peels

All potato fractions had good film-forming properties. Potato-based edible films had excellent oxygen barrier properties at low relative humidity (Table 2) and all films were totally impermeable to grease under the conditions tested. Water vapour barrier properties were, however, poor. This is typical to most biopolymer films. Suberin-rich film had higher tensile strength, tensile strain at break (ratio of deformation over initial length) and Young's modulus (a measure of the stiffness) values than the films prepared from peel mass or potato flour. Due to the inhomogeneous structure of the films prepared from unfractionated milled potato peels, their mechanical and barrier properties were not fully competitive with suberin and starch films. Anyhow, both the suberin-enriched fraction and the unfractionated potato peel mass performed promisingly as raw materials for (edible) films, but there are challenges in the utilization in practical food applications. For example, better washing of potatoes would be needed if the peelings are to be used for edible film production to ensure hygienic quality of the films. The cheap prize of pure potato starch is also hindering the use of potato co-streams in edible film production. In applications where very low price is needed, e.g. in mulch films, unfractionated potato peel mass may serve as a feasible raw material. This deserves further study.

Table 2

The effect of film composition on water vapour permeability, oxygen permeability and tensile properties

Potato fraction	**Water vapor permeability** g mm m^{-2} day^{-1}	**Oxygen permeability** cc mm m^{-2} day^{-1}		**Tensile strength** MPa	**Tensile strain at break** %	**Youngs' modulus** GPa
		0% RH, 23°C	80% RH, 23°C			
Suberin enriched	6.1	0.018	14.6	56	10	2.0
Peel mass	8.3	0.007	19.1	25	4	1.2
Potato flour	6.7	0.006	7.6	32	4	1.4

CONCLUSIONS

The interdisciplinary approach of the CYCLE project, with research institutes from the blue and green sector working closely with food and feed industry, seems to offer a promising arena for development of innovative new food and feed products. If applied to industrial scale, some of these innovations may contribute to a significant reduction in food loss at the processing stage.

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QUALITY AND SAFETY CONTROL OF AGRICULCHARAL RAW MATERIALS AND FOOD PRODUCTS USING METHODS OF GAS CHROMATOGRAPHY

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Abstract: *Three types of analytical methods currently used in the practice of analytical laboratories for quality control and food safety - local, regional and international. The quality of products intended for export to other countries is determined by the regional and international practices. This report summarizes the international methods used by the National Center for Quality Control and Food Safety Republican Unitary Enterprise “Scientific and Practical Center for Foodstuffs of the National Academy of Sciences of Belarus”*

Keywords: *Quality control, food, international methods ISO.*

INTRODUCTION

Nowadays chromatographic methods are widely used for research of quality and safety of food products. They ensures carrying out research of food composition on a lower concentration level and enables to carry out research, which cannot be done using chemical or other instrumental research methods [1]-[5]. Chromatographic methods are classified according to the type of stationary phases and mobile phase. The article presents analytical methods based on gas chromatography (GC) [6]-[8].
Gas chromatography gained advantages due to the invention of sensitive and multifunctional gas chromatographs with automatic detection and high use of highly-effective capillary columns, which effectively separate complex mixtures of organic compounds into separate components. This method is intended primarily for separation and analysis of volatile compounds (including volatile compounds at high temperatures). Nowadays it is one of the most effective ways to analyze organic components. Being both a qualitative and quantitative analysis method of complex mixtures of various organic and inorganic compounds, GC is used to study food products in a comprehensive way. From the point of view of analytical chemistry, food products are diverse objects with a complex multi-component structure. Any food product consists of a matrix (basic material of several substances - proteins, fats, carbohydrates), and many micro components of different origin (biochemical, environmental, microbiological, technological), dissolved in the matrix. The micro components have a significant impact on safety and quality parameters and include water-soluble and fat-soluble vitamins, free amino acids, organic acids, alcohols, aldehydes, aroma-active compounds, antioxidants, colorants, sweeteners, preservatives, pesticides, polychlorinated biphenyls, antibiotics, natural toxins, products of packaging destruction, etc. The knowledge of chemical composition of the matrix and micro components dispersed in it plays an important role in assessing quality and safety of food products, so the analysts` task is to carry out quantitative analysis of the matrix`s composition and the content of individual specific micro components in it for each product. Physicochemical and sensory properties of individual components in food products (molecular weight, boiling point, polarity, solubility in the matrix, taste, odor, color, etc.) may vary widely. The components responsible for sensory properties of food products are of prime importance for quality. For example, odor is generated due to the presence of volatile aroma-active components, taste is formed by water-soluble nonvolatile components (sugars, acids, etc.), while the color of the product depends on presence of colorants in the food object (chlorophyll, anthocyanins, etc.). Gas chromatography methods, based on the study of the composition in the gas phase, are perfect for identifying the composition of highly volatile components, including aroma-active compounds, which determine the product`s odor. However, many nonvolatile polar compounds can also be converted in volatile compounds using some simple chemical procedures and then they can be analyzed using the method of gas chromatography. For instance, polar fatty acids can be converted into volatile methyl or ethyl esters of acids. Sugars and polyphenols can be converted into trimethylsilyl derivatives

of sugars and polyphenols using commercially-available derivatizing agents (trimethylchlorosilanes). Such volatile derivatives are easily determined using the method of gas chromatography.

Tests of food products for the purpose of their certification should be carried out according to the procedures described in pre-developed metrological certified methodology or official standards. The availability of such official procedures and the appropriate laboratory accreditation in the State Standard Authority is an important condition to test food products. The status of official procedures to carry out analyses can be different: departmental (methodological instructions), national (standard of Belarus), regional (STB GOST R) and international. The national status belongs to the methods, developed in the organizations of the Republic of Belarus and approved by Standardization and Certification Authority in due order.

They can be used to carry out analyses for domestic purposes. To certify products to be exported outside the Republic of Belarus, it is necessary to carry out analyses according to regional or international standards. National standards are invalid outside the Republic of Belarus and for international trade the most promising standards are international standards and mainly ISO. The purpose of the paper is to review the available standard methods to analyze quality and safety of food products based on using gas- chromatographic methods to identify component composition. The main attention is paid to standard analysis methods, which are recommended by International Organization for Standardization and are considered to be basic to recognize quality and safety of food products, when they are exported abroad. Since Russia is the main importing partner of Belarusian food products, a compliance assessment of Russian and Belarusian methods with methods, recommended by the international organization ISO, is carried out.

GAS CHROMATOGRAPHIC METHOD TO IDENTIFIFY QUALITY OF ANIMAL AND VEGETABLE OILS

International Organization for Standardization has developed a number of standard methods to identify quality and safety of fats and oils. The standard ISO 5508:1990 has been developed to identify methyl esters of fatty acids using gas chromatography. In compliance with this method, a sample of fat or oil is preliminary saponified with trimethylsulfonium hydroxide according to ISO 12966-3:2009 with formation of fatty acids, which are esterified with formation of compound methyl esters of fatty acids. The content of each ester is determined using the gas chromatography method. This standard is not applicable for polymerizing fatty acids.

The standard ISO 6463:1982 is used to determine the content of food additives butylhydroxyanisole (BHA) and butylhydroxytoluene (BHT) using the method of gas-liquid chromatography in vegetable and animal oils. Butylhydroxyanisole and butylhydroxytoluene are antioxidants, which are added in fat- and oil-containing products to prevent their rancidity. These compounds are volatile and can easily be defined using gas chromatography method.The range of the determined concentrations is 2.0-12.0 mg/ml. The method is based on dissolving the oil or fat in the dissolvent and direct injection of the solution into the gas chromatograph.

Standards ISO12228-1:2014 and ISO12228-2:2014 were developed to determine the component composition and total sterol content, including cholesterol, in fats and oils. Sterols are natural alicyclic spirits, which belong to steroids, a component of the unsaponifiable fraction of animal and vegetable lipids. They are easily analyzed using gas chromatography method. The method is based on saponification of the test portion by refluxing in ethanol KOH solution. After that the unsaponified material gets isolated on a column of aluminium oxide, sterols elute from the column. Sterol fraction of the unsaponified substance separates by TLC method. Qualitative and quantitative analysis of the sterol fraction composition is carried out using GC method and betuline as the internal standard. 16 individual sterols are determined, including cholesterol and total amount of sterols.

Standard ISO 12871: 2010 is recommended to use for determining alcohol content in olive oil to identify the substitution of natural olive oil with a similar mixture of natural olive oil with the oil obtained by its pomace alcohol extraction. Oil with an internal standard α-eicosane is saponified with ethanolic potassium hydroxide and the saponified material is extracted with diethyl ether. The alcohol fraction is separated from the unsaponified fraction by chromatography on a silica gel plate; alcohols extracted from the plate, are converted into TMS-derivatives, which are determined by gas chromatography on a capillary column.

Standards ISO 15304: 2002 and ISO 12966-1:2014 can be used to determine trans-isomers in vegetable and animal oils.Increased content of trans-isomers raises the risk of cardiovascular diseases and affects the product quality. Standards ISO 15304 and ISO 12966-1:2014 establish a procedure for evaluating the content of isomers formed by thermal cleaning or hydrogenating vegetable oils or fats. The same analysis provides information about the content of other fatty acids, the amount of saturated fatty acid, total fatty acids, monosubstituted and polysubstituted fatty acids. The principle of the method can be described in the following way: methylated fatty acids are separated and analyzed on a polar phase GC column, they are eluted with a retention time, depending on the chain length, degree of unsaturation, the geometry and position of double bonds.

Gas chromatographic standard ISO 15788-1: 1999 is intended to determine stigmastadienes - compounds that are formed during heat treatment or deodorizing natural oils, so this method can detect faulty products. This standard establishes the procedure to determine stigmastadienes in natural oils with a low content of these compounds. The method is applicable to all oils, the components are reliably determined when the content of stigmastadienes ranges from 0.01 to 4.0 mg/kg. This method is used to detect refined oils in natural olive oil, as refined oil contains stigmastadienes, while cold extraction oils do not contain stigmastadienes. The detection limit of the method is 0.01 mg/kg.

Similarly, standard ISO 12873: 2010 is used to identify olive oil authenticity to determine wax content using gas chromatography. The standard establishes the procedure to determine the wax content in natural olive oils and oils obtained by extraction of the cake. Wax components are separated in accordance with the amount of atoms in a carbon skeleton. This method is recommended to recognize olive oil naturalness. The principle of the method can be described in the following way: after addition of the internal standard, oil is fractionated on a silica gel column, while the fraction of eluted triglycerides is collected and analyzed using gas chromatography method.

Two gas chromatography methods are used in the Russian Federation to determine the quality of fats and oils. The first method GOST 30984-2002, determination of butylhydroxyanisol and buthylhydroxytoluene content, corresponds to the international standard ISO 6463:1982, the second method GOST 31663-2012 is used to identify weight content of methyl ethers of individual fatty acids to their sum using gas chromatography. The method has the status of the national Russian standard.

Only one international standard STB ISO 15304-2007- Determination of trans-isomers of fatty acids in the vegetable fats and oils using gas chromatography- has been adapted in the Republic of Belarus to estimate the quality of fats and oils using gas chromatography.

STANDARD GAS CHROMATOGRAPHYC METHODS TO DETERMINE SAFETY AND QUALITY OF DAIRY PRODUCT

International Organization for Standardization has developed several gas-chromatographic methods to determine the quality and safety of milk and dairy products. Standard ISO 8260: 2008 is used to determine organochlorine pesticides and polychlorinated biphenyls in milk and dairy products using capillary column and electron-capture detector. The standard specifies a method for determination of 21 organochlorine pesticides (OCP) and 6 polychlorinated biphenyls (PCB) in milk, milk powder, in condensed milk, butter, cheese and other dairy products. The method determines OCP in the amount up to 5 µg/kg and PCB - up to 2.5 µg/kg.

Gas-chromatographic method for determination the content of triglycerides ISO 17678: 2010 is proposed to determine naturalness of milk fat. This ISO standard establishes the procedure to determine fat purity using gas chromatographic analysis of triglycerides. Both vegetable and animal fats can be determined. The authenticity of fat milk is calculated by means of triglyceride equations.The principle of the method can be described in the following way: fat is extracted out of milk or dairy products by means of a dissolvent and then analyzed using gas chromatography on a packed column or a short capillary column. Triglyceride equations are used to calculate S-coefficient. If the value of the coefficient is higher than the set value, it is assumed that an admixture of another fat is in the milk fat.

Two standards to determine sterol composition in fats are proposed to determine the quality of dehydrated milk fat. Standard ISO 12078: 2006 establishes a reference method of gas chromatographic determination of sterols in dehydrated milk fat, which is extracted from dairy products. In case of the analysis of milk fat in the mixture with vegetable fat, the method enables to evaluate the content of the most important vegetable sterols. The principle of the method can be described in the following way: internal standard (betulin) is added in a test portion of fat. After that the fat is saponified with methanolic KOH, while unsaponifiable matter becomes extracted by means of ethyl ether. Sterols become separated and converted into trimethylsilyl derivatives. The analysis with GC method is carried out using capillary column. Sterols are identified according to the retention time, while their quantity is identified using the method of internal standard.

Standard ISO 18252: 2006 defines the procedure for working gas chromatographic method to determine sterol content in dehydrated milk fat, which is extracted from the unsaponifiable matter of dairy products. The standard is used to evaluate the content of cholesterol, which makes 98% of the total content of sterols in milk fat. The method enables to assess the content of the most important phytosterols while analyzing milk fat mixed with vegetable oils. The principle of the method can be described in the following way: 5a- cholestane is added in a test portion of fat as an internal standard. After that the fat is saponified with alcoholic KOH, and unsaponifiable matter is extracted by means of ethyl ether, the extract concentrates and it is analyzed using GC method. Then sterols are identified according to retention time in the chromatogram. It is recommended to evaluate the quality of milk fat according to the composition of fatty acids. This method is established in compliance with the standard ISO 15885: 2002. Methyl esters of milk fat are made by means of trans-esterification. Separation is carried out using gas chromatography method. Individual methyl esters are determined with regard to the milk fat of the known composition.

Method ISO 23065: 2009 describes gas chromatographic procedure to determine the content of the most important omega-3 and omega-6 fatty acids in the milk fat, which was obtained from the enriched milk products. There are no adapted gas chromatographic methods ISO for determining quality and safety of milk and dairy products in the Russian Federation and the Republic of Belarus.

GOST 31979-2012, which describes the procedure for determining the content of sterols using gas chromatography method, is used in the Russian Federation for such purposes. STB GOST R 51471-2008, which is an analogue of the above mentioned Russian method, is used in the Republic of Belarus.

GAS CHROMATOGRAPHIC METHOD FOR SAFTY AND QUALITY CONTROL OF ALCOHOL DRINKS

International Organization for Standardization ISO does not provide any international standard methods to determine quality of strong alcoholic drinks. Each country, which manufactures alcoholic products, follows its national methods to analyze product quality. A number of GOSTs have been developed in the Russian Federation, which are based on gas chromatography methods for analyzing the content of volatile microcomponents, which determine aroma and safety of alcoholic products.

GOST 30536-2013 is used to determine the quality of vodka and ethyl alcohol. It describes the procedure to determine the content of 12 toxic micro-impurities (methanol, acetic aldehyde, iso-propanol, iso-butanol, amyl alcohol, etc.) using gas chromatography. A similar procedure for vodka and alcohol from food raw material is described in GOST R 51698-2000.

In addition, two GOSTs are proposed for vodka and ethyl alcohol from food raw materials: GOST 32070-2013 is used to determine the content of volatile organic acids and furfural using gas chromatography and GOST 32039-2013 regulates the procedure and rules for determining the product authenticity using gas chromatography method.

Another guideline for control of alcohol and alcohol-containing products is GOST 31811-2012, which describes the procedure for gas chromatographic determination of croton aldehyde. In compliance with GOST 31684-2012 the control of raw alcohol from food raw materials is carried out using gas chromatographic method to determine the content of micro impurities.

In the Republic of Belarus the quality control of vodka and ethyl alcohol from food raw materials is carried out according to the adjusted document - STB GOST R 51698-2001 and GOST 31684-2012. The documents describe a gas chromatographic express method for determination of the main toxic volatile micro impurities. Other gas chromatographic methods for quality control of alcohol-containing products are not provided.

GAS CHROMATOGRAPHYC METHODS FOR DETERMINING THE QUALITY OF OTHER PRODUCTS

Gas chromatography method is also used for other food products. The international standard ISO 11215: 1998 has been proposed to determine adipic acid in adipates of modified starch. GOST 30669-2000 offers a method to determine benzoic acid, while GOST 30670-2000 offers determination of sorbic acid in derivative products of fruit and vegetables using gas chromatography method.

GOST R 51822-2001 is used for wine and wine materials. It is intended to be used to determine the volume ratio of ethyl alcohol and mass concentration of acetic and propionic acids.

CONCLUSION

To sum up, International Organization for Standardization ISO recommends 16 international standards for assessment of the quality of food products, which involve gas chromatography. In Russia there exist 9 regulatory documents for similar purposes, including one of them, which was harmonized with ISO standard.

Methodical basis in Belarus includes only 4 standards for using GC methods for assessing the quality of similar products. Among them 3 standards have been harmonized with the Russian standards and one standard has been harmonized with European regulatory documents.In connection with the prospect to increase exports of Belarusian products it is necessary to significantly intensify efforts to adapt international standards ISO and adopt them into practice of testing laboratories in the nearest future.

Lack of standards with an international status can become an impediment for international recognition of quality test results of domestic food products.

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FISH PRODUCTION, CONSUMPTION AND MANAGEMENT IN ETHIOPIA

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Abstract. *This review paper was conducted to analyses the fish production, consumption and management trends in Ethiopia. The data was collected from primary and more secondary data. Following Eritrea's secession from Ethiopia in 1993 and the consequent loss of its coastline, Ethiopia has only inland freshwater capture fisheries. There are 180 different species of fish in Ethiopia and 30 of those are native to the country. The total area of the lakes and reservoirs stands at about 7000 to 8000 km^2 and the important rivers stretch over 7000 km in the country. Fishing contribution for country's GDP is very low. Fish production potential of the country's estimated 51,000 tonnes. Fresh fish are consumed in the vicinity of the Great Rift Valley lakes. Outside these areas, the domestic market for fish is small. Since fishery production is overexploited due to inappropriate fishing practice the potential of fish was underdeveloped and the management rule and regulation at federal level and regional level to control the devastation was very poor.*

Key words: *Fish, production, management, Ethiopia.*

DETERMINATION OF CONSUMER PREFERENCES FOR FRESH FRUIT AND VEGETABLE IN TERMS OF FOOD SAFETY: A CASE STUDY OF CANAKKALE PROVINCE

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Abstract: *Fruit and vegetable production have a significant place in the Turkish agricultural production due to suitable climatic and natural conditions. Also, Turkey has a huge production capacity and with ever increasing competitive structure in both fresh fruit and vegetable production and exportation. According to the average of 2010-2012 years, the share of fruit and vegetable in total agricultural products exportation value from Turkey to the European Union (EU-27) is 33.4%. The share of fruit and vegetable in the marketed crop product value is 62.8% according to the average of 2011-2013 years in Turkey. In the same period, the share of fresh fruit and vegetable in Canakkale province's total crop products value is 50.2%. In the last years, the most important problems in the fruit and vegetable trade in all of the world are non-authorized pesticides, pesticide residues exceeding permissible limits, packaging requirements, with contaminants exceeding regulatory levels, and/or with inadequate general quality. Consumers in the producer countries and domestic markets are also affected these food safety problems. The aim of this study is to determine fruit and vegetable consumption decisions of consumers who live in Canakkale province in terms of food safety. Data of the study will be collected from 166 consumers determined using simple random sampling. The Five-Point Likert Scale will be used in measuring some views of the consumers. Factor analysis and logistic regression will be used to analyze the data.*

Key Words: *Fruit and Vegetable, Consumer Preference, Food Safety, Canakkale, Turkey.*

ECOLOGICAL ARGUMENTS FOR LOCAL FOOD ENTREPRENEURS

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Abstract. *The aim of this study was to develop a framework that includes measures, criteria and document-based arguments for ecological sustainability of Finnish local food. Our framework consists on several aspects of ecological sustainability: nutritional value of food, use of local resources in food production, eutrophication, ecotoxic and toxic impacts of used hazardous substances in food production, impacts of food production on biodiversity and ecosystem services and climate impact of food production. The arguments found in the project to support ecological sustainability of local food were aggregated into so-called argument bank.*

The local food sector enterprises can use the arguments to increase ecological sustainability in their functions concerning local food and to communication and marketing. In addition to the production side, consumer-focused versions of arguments were used for local food consumers in order to help them specify their demands for food sustainability. Arguments can be found in various chain actions in food production chain (e.g. agricultural production, processing, transportation), where they increase ecological sustainability. Communication and collaboration among stakeholders should be enhanced. It is important to produce knowledge and communicate it within and among local consumer groups.

Key words: *local food, ecological sustainability, indicator, environmental impact assessment, communication.*

INTRODUCTION

Local food is emphasized in Finnish food policy, because it is considered to be sustainable as it supports local economy, employment and food culture. Finnish consumer value local food and they appreciate if it is produced in an environmentally friendly way [6]. It has been studied that local food production can increase sustainable development in some aspects [e.g. 3, 7, 11, 12, 15]. But also a lower environmental impact of local food has been questioned in scientific literature [e.g. 1]. However, ecological sustainability of local food production has not been studied extensively in Finland or internationally.

In this study, we aim to develop a framework that includes measures, criteria and document-based arguments for ecological sustainability of Finnish local food. Our framework leans on the theory of resilience [e.g. 4], an agroecological view of sustainable agriculture [5] and the most critical global environmental problems [13]. The framework consists on several aspects of ecological sustainability: nutritional value of food, use of local resources in food production, climate change and eutrophication of food production (consumption chains), ecotoxic and toxic impacts of used hazardous substances in food production and impacts of food production on biodiversity and ecosystem services. These aspects assumed to represent the most critical environmental impacts and ecological issues related to food production and consumption, and presumably they vary between local and mainstream food systems.

Arguments were developed to support ecological sustainability of local food and they were constructed into a so called argument bank. One aim of this task was also to support ecological sustainability of local food enterprises in terms of communication and marketing. In addition to the production side, consumer-focused versions of arguments were used for local food consumers in order to help them specify their demands for food sustainability.

MATERIALS AND METHODS

The framework was tested for ecological sustainability of local food chains from three different regions in Finland, from the southern coast (Southern Finland, numbered as 1) to the southern inland region (Häme, numbered as 2) and reaching the central inland region (Central Finland, numbered as 3). The studied areas are shown in figure 1.

The basis of sustainable use of resources and sensitivity to environmental impacts in the three regions were evaluated according to geography and the context of consumption-production. Life Cycle Assessment

(=LCA) based product-specific indicators for ecological sustainability were tested for 14 local food chains (included 38 companies) in the three regions. In each region, typical local products of high commercial interest were tested and chain-specific data were collected directly from stakeholders. The products of the area 1 were organic rye bread, organic crushed peas, organic crushed broad beans and mashed potatoes. The products of the area 2 were rye bread, carrot and beef. Products in area 3 were organic rye bread, blackcurrant juice, organic honey, beef, canned elk meat and fromage frais.

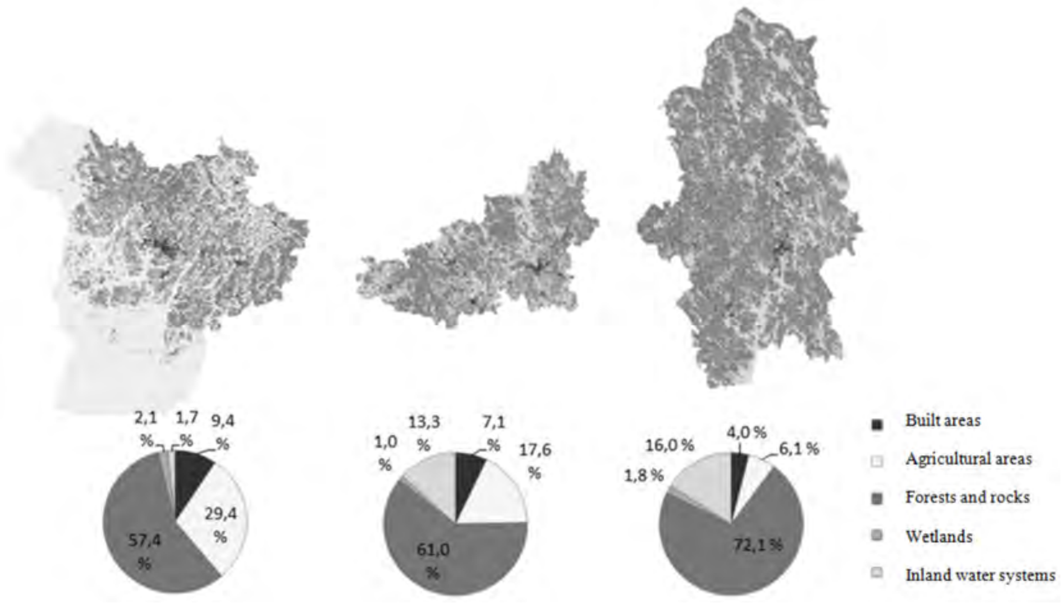

Figure 1. **The framework was tested for ecological sustainability of local food chains from three different regions in Finland, from the southern coast (Southern Finland, numbered as 1) to the southern inland region (Häme, numbered as 2), reaching the central inland region (Central Finland, numbered as 3) [8].**

Climate impact and eutrophication impacts were included as impact categories, when conducting LCAs of the pilot chains. All chains covered phases "from field to grocery", i.e. primary production, processing, packaging and transport phases, including the grocery store, commercial kitchen or local food establishment. Units were expressed as kg CO_2-ekv.kg product and g PO_4-ekv/kg product, respectively. In addition, Life Cycle Assessment based potential ecotoxicity impacts of used pesticides on fields of the studied chains were calculated with the SETAC consensus LCIA model USEtox™, and PestLCI 2.0 was used to model emissions with average Finnish field conditions. Ecotoxicity was calculated only for active ingredients that had a characterization factors in our study, 72 ingredients in this case. CTU (=comparative toxic unit) was used as a unit. From all food chains in this study, only four farms used pesticides. In addition, factors that affected farm biodiversity were evaluated using a questionnaire provided to farmers. That focused on environmental activities that support biodiversity carried out on-farm. Those results were compared to the general used activities in Finnish farms.

RESULTS AND DISCUSSION

The nutritional value of food represented the basis for assessment of ecological sustainability, in accordance with the national nutrition guidelines. Sustainability of local resource use was directly linked to land use, efficiency of resource use and side flows, accuracy of nutrient recycling and utilization of local energy sources. Food production sector of the regions were different from each other. For example environmental impacts of rye bread product chain were very different in each pilot areas. The reason was different circumstances of cultivation which had impacts on yield, greenhouse gas emissions and nutrient leaches. Area 1 has very much fields compared to area 2 and 3, and area 2 and 3 had large forest areas and lakes. Area 3 had the lowest population density and area 1 the highest. The production volumes of different food sectors were different. Bringing seasonal food into play provides unique opportunities for local food production.

An overview of the LCA based results (climate change and eutrophication) showed that some of the local products induced higher, and other lower, impacts than similar products in an average Finnish production chain. Product-specific impacts of climate change on local food were chain specific and typically animal-based products had higher impact than plant based ones. However, locally based game products such as moose had a very low climate change impact. The overall problem with local food is that its logistics have developed in line with mainstream production. Transportation created relatively high climate impact for some products. Specific logistics should be applied to meet the specific demands of local food better. Climate impact results can be seen in figure 2a and 2b.

2a 2b

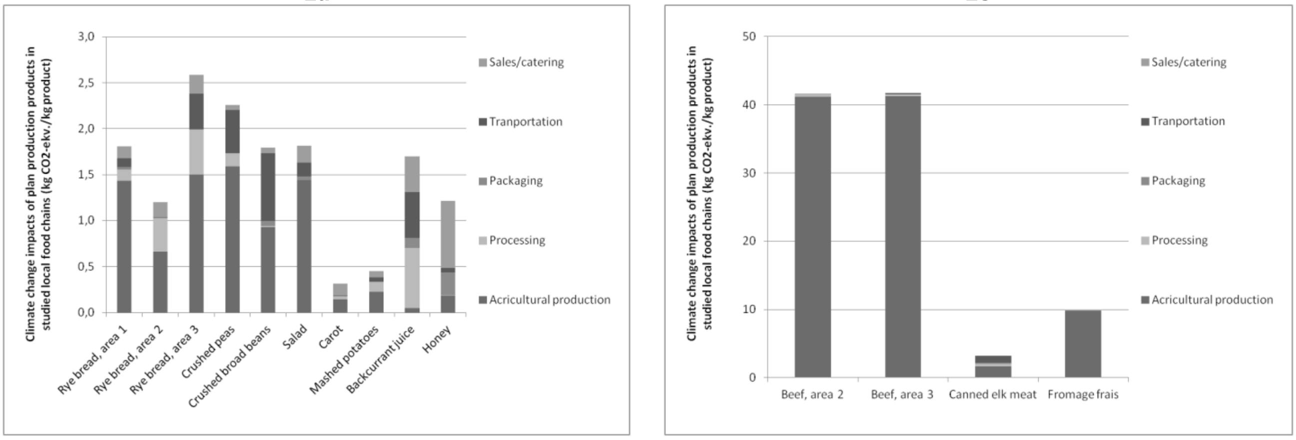

Figure 2 a and b. **Climate change impacts of plant (left) and animal (right) products in studied local food production chains (kg CO_2-ekv.kg product). The local food chains located in three different areas in Finland. They were numbered as 1, 2 and 3 because companies cannot be linked to the area or other specific information can not be published of them.**

Eutrophication and biodiversity impacts of local food are particularly dependent on sensitivity of the local environment. The results need to be carefully assessed in the context of local circumstances. Eutrophocation impacts were mostly originated from agricultural production. Soil type had a great impact in eutrophication. Product-specific impacts of eutrophication on local food were chain specific and typically animal-based products had higher impact than plant based ones. Local food production represents many opportunities to support biodiversity. A simple survey in this study indicated that local food producers could become more interested in environmental matters. A questionnaire based results showed that local food farmers used more actions that increase biodiversity in their field than generally in Finnish farms [10]. In general terms, local food has good potential to support ecosystem services through biodiversity and recycling of resources.

There was a wide range of pesticide use (quantity and quality of the pesticide) in local food farms between produced plant, year and used pesticide. E.g. growth factors were the most used plant protection products in a farm that produced rye over 2010–2012 but also herbicides were used there. In addition, fungicides were used in one year (2012). Herbicides were the most used plant protection products in a carrot farm over 2010–2012 but also insecticides were used there. There were used many different pesticides in both rye and carrot farms but total ecotoxicity impact was less in rye than carrot farm depending on used pesticide. In addition, ecotoxicity impact of local food production ranged from insignificant to highly hazardous depending on used pesticides. E.g. herbicide aclonifen's (used in carrot) and fungicide fluazinam's (used in potato) impact can be over thousands times more than herbicide glyphosate (used in rye and black currant). There can be wide range of the impacts between different chemicals [13]. The reason for the chemical usage can be e.g. weather conditions in a specific growth season, local soil and other geographical conditions of the field, a farmer's choice e.g. to avoid resistance but also achieve a good yield. In EU plant protection should be done according to IPM (Integrated Pest Management) [2].

An argument bank was constructed according to the results. The arguments were based on identification of actual tasks that should be undertaken to enhance ecological sustainability of a local product. The nutritional value of food for argument bank was qualitatively discussed accordance with the national nutrition guidelines. Also Finnish agricultural program [9] expressing the national agricultural management was used as a base for the arguments. The LCA based indicators were included for quantitative measures to be used to monitor the level of sustainability. For those tasks, where quantitative indicators were missing, a qualitative description was used to document activities. The argument bank was published as a separate booklet available on the web http://www.utu.fi/fi/yksikot/braheadevelopment/palvelut/osaamisalueet/elintarvikeala/Sivut/lahiruoan-ekologia.aspx. Examples of the arguments to support decreasing of eutrophication and climate change impact have been shown in table 1.

Table 1

Examples of the arguments for producers and consumers to support the decreasing of eutrophication and climate impact

Impact	Argument for producers	Argument for consumers
Impact on eutrophication	Grasses for environmental treatment, plant coverage of fields and use of organic materials can be utilized in locally important areas concerning protection of water systems. Wetlands can be established to places, where they naturally belong. Eutrophication impact can be calculated and assessed its significance in relation to the total nutrient loads and eutrophication impact of local ecosystem. After that the required improvement actions are made.	Grasses for environmental treatment, plant coverage of fields and use of organic materials can be utilized in locally important areas concerning protection of water systems contribute to visible biodiversity and positiveness of protection of local water system. Eutrophication impact has been calculated and it is in acceptable level also when compared to the eutrophication impacts of products produced in alternative regions.
Impact on climate change	Grasses for environmental treatment, plant coverage of fields and use of organic materials have been introduced. Use of slurry has been introduced. Recycling of organic material has been introduced. Logistics, production and storage are efficient. Use of organic soils in annual cultivation is avoided.	Grasses and, plant coverage of fields reduce greenhouse gas emissions. Use of slurry has been introduced. Efficient technical implementation for use of slurry reduces smell disadvantages and greenhouse gas emissions. Utilization of local products contributes to recycling of organic materials. Carbon footprint of storage and logistics has been assessed and is in acceptable level. The relationship between renewable and unrenewable energy is known and it is in accetable level or better than the relationship of products produced in alternative regions. Carbon footprint of local product has been assessed and it is in accetable level also when compared to products produced in alternative regions.

CONCLUSIONS

The aim of this study was to develop a framework that includes measures, criteria and document-based arguments for ecological sustainability of Finnish local food. Our framework consists on several aspects of ecological sustainability: nutritional value of food, use of local resources in food production, eutrophication, ecotoxic and toxic impacts of used hazardous substances in food production, impacts of food production on biodiversity and ecosystem services and climate change of food production.

The conclusions based on LCA case-studies are that concerning climate impact and eutrophication impact the results are case-specific. In some cases local food has lower and in some cases higher environmental impacts than mainstream production. Regional differences in production of local food products can be remarkable. Very important parameters in the agricultural production were obtained yield and soil type of the cultivation as big part of organic soil in agriculture leads to high greenhouse gas emissions. When the yield is low, nutrient leach per amount of produced crop can increase remarkably.

Also transports can have remarkable climate impact, if the loads or transport routes are not optimized. Climate change impact can be increased in regions with low population densities. Chemical use and impact on sustainability of local food production ranged between plant production and year from insignificant to highly hazardous depending on quantity and quality of used pesticides. Chemical control can be used only if preventative measures do not adequately suffice for plant health and economic value of the yield according to IPM. Local food farmers used more actions that increase biodiversity in their field than generally in Finnish farms. Thus, local food has good potential to support ecosystem services through biodiversity resources.

In addition, the arguments of whole framework to support ecological sustainability of local food were included into a summary of the findings, which were included in the argument bank. Some of the arguments were improvements, which were made by taken into account local conditions, like establishment of wetlands and some general improvements like optimizing transports, storage and recycling of nutrients. The enterprises can find arguments from argument bank to increase ecological sustainability in their local food production and use those ones in terms of communication and marketing. In addition to the production side, consumer-focused versions of arguments were used for local food consumers in order to help them specify their demands for ecological sustainability of food production. Arguments can be found all over the whole food chain (e.g. agricultural production, processing and transportation) and special actions in the production can be affected for increase the ecological sustainability. Finally, communication and collaboration among stakeholders should be enhanced. It is important to produce knowledge of the production phases that affect to the ecological sustainability and communicate it within and among local producers and consumer groups also in the future.

A research report of this study in Finnish is available http://urn.fi/URN:ISBN:978-952-487-538-7.

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ACCEPTANCE OF THE MOST COMMON QUALITY ATTRIBUTES OF ORGANIC FOOD IN THE FINNISH FOOD CHAIN

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Abstract. *The aim of this study was to establish the degree of acceptance of organic food production and food in the Finnish food chain. The organic food system in Finland is poorly developed and one of the many reasons is that the food chain stakeholders are not committed and do not share common objectives for organic food and its production. A survey was carried among 1527 respondents from agriculture, industry, retail, catering and consumers to establish their opinions on safety and healthiness of organic food, and ecology and ethicality of organic production as well as the support that their own environment provided to their opinions. The results show that all environments are very positive for all four attributes. The best support for positive opinions on organic food and its production was in retail and catering. The community, as a consumer's environment was the least supportive of positive opinions and did not provide enough information about organic food and its production. To develop the organic food system, there needs to be a common objective among all stakeholders. Safety, healthiness, ecology and ethicality, as commonly accepted attributes, could represent tools for a more sustainable food system. Accepting consumers as co-creators in the food chain would enrich communication and strengthen the positive development of the entire organic food chain.*

Key words: *organic food, food chain, acceptance, quality.*

INTRODUCTION

The organic food system is poorly developed in Finland comparing it with several other European Community member countries [1] and has not reached the goals set by the Finnish government for its share of the agricultural area or the markets [2], or for sustainable public catering [3]. One of the reasons is that conventional Finnish food is regarded as "almost organic" [4] and the Finns do not find sufficient reason to buy organically produced food [5]. The interest and commitment from all stakeholders in the food chain is needed to enable development of the organic food chain [6]. There have been barometer studies on Finnish consumer attitudes towards organic food [7] and studies on consumption behaviour [8], but nothing has been done at the food chain level.

The aim of this study was to establish the level of acceptance of organic food production and food in the Finnish food chain. Acceptance was tested using a survey where food or food production quality-related attributes were presented in an organic food context: safety and healthiness of food and ecology and ethicality of the food production. Those four attributes were chosen because they are among the most commonly mentioned in consumer studies to describe organic food and organic production. The most commonly mentioned attribute, however, is taste [8],[9], but because taste is difficult to define and is highly personal, it was not included in this research.

Consumers find organic food 1) *safe*, because it has fewer residues from pesticides [10] and medications [11], fewer additives [12] and no GMOs [13], 2) *healthy* [14] and healthier [15] than conventional food, 3) *ecological*, because it is good for the environment[16], better for the environment than conventional [17], maintains biodiversity [18] and has less negative impact on nature [19], and 4) *ethicality*, for better animal welfare [20], living conditions of animals [21] and natural breeding [22].

MATERIALS AND METHODS

The food chain environments chosen for this study were agriculture, the food industry, retail and catering. Society was regarded as the environment of the consumers. The consumer survey was outsourced to achieve optimal sampling. For other environments, the respondents were approached through their employers, professional associations or lobbyist by a letter informing about the survey and that a link to the survey would be sent to them by e-mail to be distributed to their employees or members. The sample sizes were not large enough for environments other than the consumers (N= 1096, others 50-158), so the results cannot therefore

represent those environments, but are indicative nonetheless. The survey was carried out in May-June 2012 using the Webropol internet-based system. Analysis of the results was done in June-August 2012 with the Webropol professional analysis tool.
The questionnaire contained 1) demographic questions, 2) environmental questions, 3) sub-environmental questions (e.g. food industry size, communal or private catering), 4) questions on food safety, healthiness, ecology and ethicality e.g. "*in my opinion, organic food is safer than conventional food*", 5) questions about own environment's support for respondents' own opinions e.g. "*in my opinion I get support from my environment for my opinions on the ethicality of organic production*, 6) questions about the information available on the safety and healthiness of organic food and ecology and ethicality of organic production e.g. "*I get enough information on the healthiness of organic food from my environment*". Options for responding to questions 4-6 were "*agree*" or "*disagree*".

Demographic description of the sample

Of all respondents (N=1527) 53% were female and 47% male. There were more male respondents in industry and fewer in catering. 69% of the total lived in cities, 81% people worked in retail and of those 82% in retail chains (private shops 76%). 20% of the agricultural producers lived outside the countryside (33% potato and vegetable producers). 83% of the respondents from big industry (more than 100 employees) lived in cities and 55 % were from small industry (fewer than 10 employees). Most of the respondents lived in the southern (41%) and in the western parts of Finland (35%). The demographic description of the sample is given in Table 1.

Table 1

The demographic description of the sample

Factor group	Factor	All (N=1527)	Agriculture (N=136)	Industry (N=50)	Retail (N=87)	Catering (N=158)	Consumers (N=1096)
Sex	Female	52,5%	42,6%	42,0%	48,3%	56,3%	54,0%
	Male	47,5%	57,3%	58,0%	51,7%	43,7%	46,0%
Province	Southern F.	41,0%	26,5%	50,0%	55,2%	46,2%	41,1%
	Western F.	34,5%	46,3%	30,0%	27,6%	32,3%	35,3%
	Oulu	9,0%	6,6%	6,0%	4,6%	7,6%	10,3%
	Lapland	3,5%	3,7%	2,0%	1,2%	1,3%	3,2%
	Eastern F.	11,0%	16,9%	12,0%	11,5%	12,7%	10,1%
Municipality	City	68,6%	14,7%	72,0%	80,5%	70,9%	73,8%
	Urban	13,4%	5,2%	6,0%	10,3%	12,7%	15,2%
	Countryside	18,0%	80,2%	22,0%	9,2%	16,5%	11,0%

RESULTS AND DISCUSSION

The highest share of positive answers per environment for the four arguments was in catering (82%) and among consumers (80%). The lowest share was in industry (68%). The conventional and organic producers exhibited the biggest and most significant ($p<0,01$) difference regarding their positive views on organic food and its production: food safety organic 97% and conventional 37%, healthiness: organic 96% and conventional 35%, ecology: organic 99% and conventional 48% and ethicality: organic 99% and conventional 46%. Female respondents were more positive than male (e.g. ethicality: female 89% and men 82%, $p<0,01$), respondents from Lapland less positive that those from other provinces (e.g. healthiness: Lapland 56%, $p<0,01$, others 75%-81%). The consumers using organic products were more positive regarding organic food and its production than others (e.g. ecology: users 88% and non-users 56%, $p\leq0,05$). The best support for positive opinions regarding organic food and its production came from retail (80%) and agriculture (71%). 45% ($p<0,01$) of consumers felt support for their positive opinions. 70% of the respondents from industry got enough information about organic food and its production. 53% of the consumers answered that they received sufficient information. The statistically significant results for opinions, support and information are presented at environmental and sub-environmental levels. The shares of positive opinions are given in Figure 1. and the shares of environmental support for those with positive opinions in Figure 2.

Safety of organic food

75% of all respondents considered organic food to be safer than conventional food. The most positive responses were from catering (80%) and retail (78%), and the least positive from industry (58%, p<0,01) especially from the larger companies (33%, p<0,01) and meat industry (29%, p<0,01). The greatest environmental support was from retail (81%), especially food stores (92% and supermarket chains 76%). 33% (p<0,01) of those who considered organic food not to be safer than conventional got support for their opinion (highest for big industry 61%). 52% (p<0,01) of consumers got enough information about the safety aspects of organic food. Most information was available in industry (74%, p<0,01). Respondents from the countryside most easily got information (64%, p<0,01, urban 51%, city 55%).

Healthiness of organic food

75% of all respondents considered organic food to be healthier than conventional food. The most positive responses were from catering (78%) and consumers (76%), and the least positive from industry (62%, p≤0,05) especially from large companies (33%, p<0,01). Most environmental support was from retail (81%), especially food stores (85%, p<0,01) and the lowest from big industry (50%) and public catering (53%, p<0,01). 33% (p<0,01) of those who considered organic food not to be healthier than conventional got support for their opinion. 52% (p<0,01) of consumers got enough information about the healthiness of organic food. Most information was available from agriculture (68%, p<0,01) and industry (65%, p<0,01). Respondents from the countryside most easily got information (63%, urban 53 %, city 55%, p<0,01).

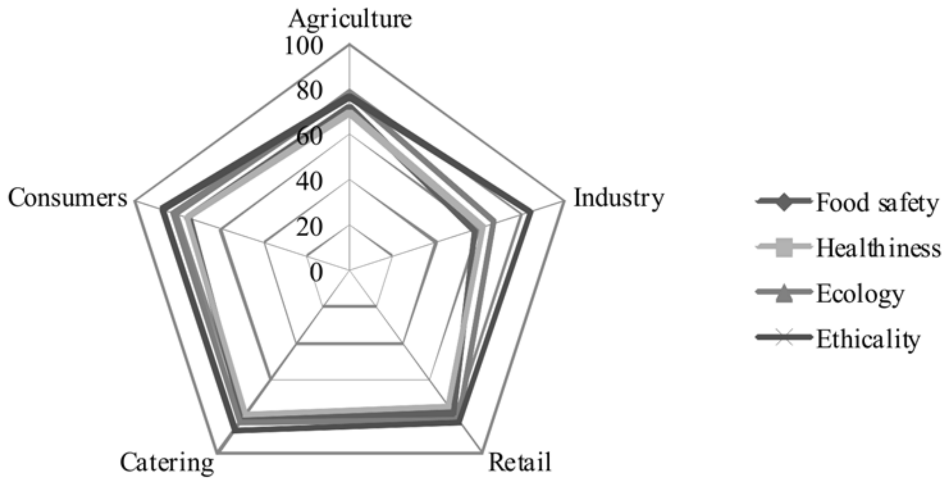

Figure 1. **Shares (%) of positive opinions on safety and healthiness of organic food and ecology and ethicality of organic production per environment**

Ecology of organic production

81% of all respondents considered organic production to be more ecological than conventional production. The most positive respondents were from catering (83%), retail (82%) and consumers (82%), and the least from industry (67%, p≤0,05), especially large companies (50%, p≤0,05). Most environmental support was from retail (78%, p<0,01) and least from consumers (49%, p<0,01) and big industry (47%, p<0,01), where there was most support for those who did not find organic food to be more ecological than conventional (31%, p<0,01). 52% (p<0,01) of consumers got enough information about the ecology of organic production. Most information was available from agriculture (69%, p<0,01) and industry (71%, p≤0,05).

Ethicality of organic production

86% of all respondents found organic production to be more ethical than conventional production. The most positive responses were from catering (87%) and consumers (87%), and the least from agriculture (76%, p<0,01) especially milk producers (60%, p≤0,05) and big industry (56%, p<0,01). 62% (p<0,01) of those who considered organic production to be more ethical than conventional got support from their environment. Most support was from retail (82%, $p<0,01$) and least from consumers (52%, $p<0,01$) and public catering (41%, $p<0,01$). 29% ($p<0,01$) of those who considered organic food not to be safer than conventional got support for their opinion. 53% ($p<0,01$) of consumers got sufficient information about the safety of organic food. Most information was available from agriculture (70%, $p<0,01$) and retail (70%, $p\leq0,05$). Respondents from the countryside most easily got information (64%, $p<0,01$, urban 55%, city 57%).

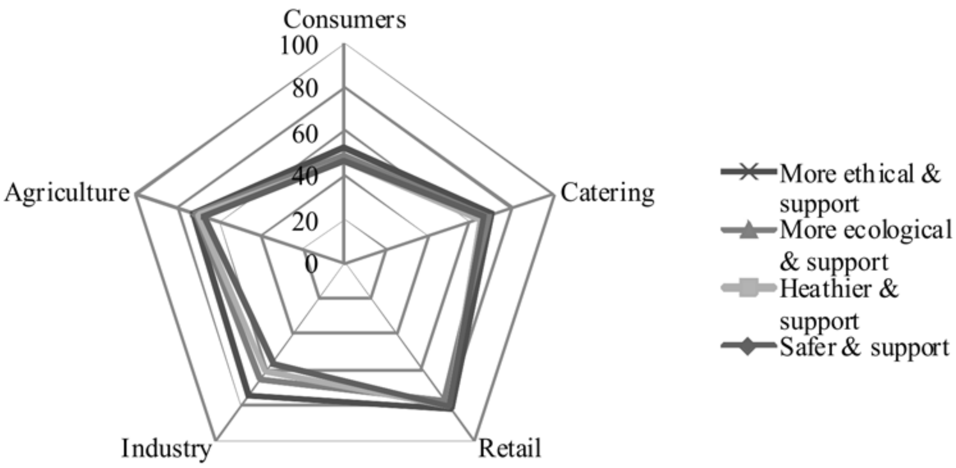

Figure 2. **Shares (%) of support from the environment for the positive opinions on safety and healthiness of organic food and ecology and ethicality of organic production**

Discussion

There were no similar studies available for comparison of these results. The literature supports the choice of the quality attributes as well as their acceptance in general [23]. Although the information available reflects the opinions on organic food and its production [6] and 44% of the respondents in this study did not get enough information from their environment, the entire food chain was very positive towards the four most commonly mentioned quality attributes of organic food and its production. The community, which was regarded as the consumers' environment, gave significantly less support to the consumers' positive opinions on organic food and production than other environments did for their members. Support needs acceptance, the right values and motivation, and is based on information [24],[25]**.** It is easy to understand that information is more easily available to respondents working in the food chain than in other professions.

Some of the differences between environments and sub-environments were expected, such as organic farmers being more positive than conventional farmers regarding organic production. One of the reasons for the good results from retail and catering might be that those environments have not been implicated in the negative impacts like GMO, pesticide residues, additives, pollution or unethical treatment of production animals of conventional food and its production. This result supports such observations. Attitude is something that is learned and the more credence given to organic or conventional production in terms of ecology or ethicality, for example, the stronger become attitudes associated with the two production systems [26]. After several food scandals, consumers have become increasingly interested in their food and many consider organic food to be a good option. Acceptance is a result of support from the environment and members' opinions [24]. According to the findings of this study, acceptance was strongest for the retail and catering sectors.

CONCLUSIONS

It is impossible to develop the organic food chain unless stakeholders share a common objective and have the tools to realise it [27]. This study has indicated that safety, healthiness, ecology and ethicality of organic food and its production have good support from the food chain. Therefore, those should be taken as values and tools [28] in addition to the economical measures [29] to shape the food chain towards becoming more sustainable through development based on the principles of common good [30]. Consumers value safety and healthiness in food, as well as the ecological implications and ethicality of production. The literature strongly supports such views. Consumers should be accepted as co-creators and co-innovators [31]. There remain several bottlenecks in the organic food chain. This study has shown that the food chain stakeholders in Finland share their attitudes and acceptance of organic food and its production. Open discussion on the benefits of organic food and its production is needed to address the current lack of information on its merits and demerits.

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MICROBIOLOGICAL QUALITY OF RAW FISH AT RETAIL MARKET IN LATVIA

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Abstract. *The aim of the study was to evaluate the microbiological quality of raw fish obtained from retail market. Overall, 20 raw fish samples, including roach (Rutilus rutilus), crucian carp (Carassius carassius), European perch (Perca fluviatilis), silver bream (Blicca bjoerkna) and round gobby (Neogobius melanostomus) were collected during October, 2014. Samples were analyzed for total bacterial count, Enterobacteriaceae count, Escherichia coli, Listeria monocytogenes and Salmonella. Total bacterial count in raw fish ranged from 5.58 to 7.84 log_{10} CFU cm^{-2}. Total bacterial count in silver bream (7.57 log_{10} CFU cm^{-2}) were significantly higher ($p<0.05$) than in round gobby (6.31 log_{10} CFU cm^{-2}). Enterobacteriaceae counts ranged from 1.91 to 5.28 log_{10} CFU cm^{-2}, and there were no significant differences ($p<0.05$) between fish species. E. coli was detected in three of 20 fish samples analyzed and E. coli count ranged from 1.11 to 1.72 log_{10} CFU cm^{-2}. Overall 11 from 20 fish samples tested were positive for L. monocytogenes. However, all the samples were negative for Salmonella. This study demonstrates that high total bacterial count and Enterobacteriaceae numbers were determined in raw fish samples, as well as raw fish at retail level can serve as the potential reservoirs of L. monocytogenes.*

Key words: *raw fish, microbiological quality, Listeria monocytogenes, Salmonella.*

INTRODUCTION

Fish are a source of high quality animal protein, containing considerable quantities of valuable lipids, minerals and vitamins. It is assumed that freshwater fish products are healthy food for human nutrition [1]. On the contrary, fish nutrient composition and high moisture content allow the growth of a large range of microorganisms, which affect fish quality and safety rendering fish unacceptable for human consumption [2]. Microbiological quality of raw fish results from microbiological load of aquatic habitat, methods of capture, transportation, chilling and storage conditions [3],[4].

Total bacterial count (TBC), *Enterobacteriaceae* and *Escherichia coli* are frequently used as criteria to assess the quality and safety of foods. TBC is used to assess the general microbiological quality of fish and can be a useful indicator to predict the shelf life of raw fish [5]. *Enterobacteriaceae* and *E. coli* are used as indicators of the potential presence of pathogens and indicating hygienic status of fish [6].

Several pathogenic bacteria may either be present in the environment or contaminate fish during handling [7]. *Salmonella* and *Listeria monocytogenes* are reported to cause foodborne infection in humans by the ingestion of raw or inadequately processed contaminated fish or fish products [8]-[11]. Pathogenic bacteria can be transmitted to consumer by raw products at retail level, which develop the threat of food-borne infections [12],[13]. Therefore detection of microbiological quality and pathogens in raw products is crucial for the identification and prevention of issues related to public health and safety.

Several studies of microbiological safety and quality of raw fish in Europe have been performed [10],[14]-[16]. However, limited data on hygiene indicators and the prevalence of pathogens in raw fish at retail level in Latvia have been available. The objective of this study was to assess raw fish microbiological quality by detection of total bacterial count, *Enterobacteriaceae* and *E. coli* counts and the prevalence of *Salmonella* and *L. monocytogenes* in raw fish from retail market in Latvia.

MATERIALS AND METHODS

Fish samples

Raw, whole fish were purchased from one fish market in Riga, Latvia during October 2014. Overall, 20 samples including four roach (*Rutilus rutilus*), five crucian carp (*Carassius carassius*), five European perch (*Perca fluviatilis*), three silver bream (*Blicca bjoerkna*) and three round gobby (*Neogobius melanostomus*) were taken. Samples were collected in plastic bags, chilled below 4°C, transported to the laboratory and tested within one hour.

Sample preparation

For detection of TBC, *Enterobacteriaceae* and *E. coli* surface samples of fish skin were collected with abrasive sponge moisturized with 0.1% peptone water by covering a 25 cm^2 or 100 cm^2 area of fish skin depending on fish size. Samples for detection of *Salmonella* and *L. monocytogenes* were consisted of pooled sample of skin, musculature and intestinal tract of each fish. In total, 25 g of material was used for detection of each pathogen.

Bacteriological analysis

For TBC and *Enterobacteriaceae* 10-fold dilutions of initial surface samples of fish skin were prepared and 1 ml of each dilution transferred into duplicate plates of Plate Count Agar (PCA, Biolife Italiana S.r.l, Milan, Italy) for TBC and violet red bile glucose agar (VRBG, Biolife) for *Enterobacteriaceae*. Inoculated PCA plates were incubated at 30°C for 72 h, according to the ISO 4332 [17] and all colonies were enumerated after incubation. Inoculated VRBG plates were incubated at 37°C for 24 h according to the ISO 21528-2 [18], using duplicate plates of and incubated at 37°C for 24 h, followed by manual counting of typical colonies.
The detection of *E. coli* was performed according to ISO 7251 [19]. An amount of 1 ml from each decimal dilution (from 10^{-1} to 10^{-5}) of the sample inoculated into 10 ml lauryl sulfate broth (Biolife). The tubes were incubated at 37 °C and after 24 h examined for gas production. Gas-negative tubes were re-incubated for an additional 24 h and reactions examined again. One 10-µl loopful of material from each tube with positive gas formation was inoculated into a tube containing 10 ml of *Escherichia coli* (EC) broth (Biolife), incubated at 44°C for 24-48 h and examined for the presence of gas production. After evalution, gas positive EC broth tubes were transferred in tripton water (TW, Biolife) and further incubated at 44°C for 48 h. Finally, the indole test was performed for the presence of *E. coli.*
The detection of *Salmonella* was done according to ISO 6579 [20]. Briefly, 25 g from each of fish samples were homogenized with 225 ml of buffered peptone water (Biolife) in stomacher for 60 s and incubated at 37°C for 18 h. An inoculum from pre-enrichment broth was inoculated into each of Rappaport Vassilliadis broth (RV, Biolife) and Muller-Kaufmann tetrathionate novobiocin broth (MKTTn, Biolife). The RV broth was incubated at 41.5°C for 24 h, while MKTTn broth at 37°C for 24 h. From both cultures, 0.1 ml was plated onto two selective solid media: xylose-lysine-desoxycholate agar (XLD, Biolife) and brilliant green agar (BGA, Biolife) and further incubated at 37°C for 24 h and examined for the presence of presumptive colonies.
The standard ISO 11290-1 [21] method was used for *L. monocytogenes* detection. An amount of 25 g of sample was added to 225 ml Half-Fraser broth (HF, Biolife) followed by homogenization for 60 seconds in a stomacher and incubated for 24 h at 30°C. Thereafter 0.1 ml aliquots of the HF broth were transferred to 10 ml of Fraser broth (Biolife) and incubated at 37°C for 48 h. An amount of 0.1 ml of both, Half-Fraser and Fraser enrichments were streaked onto Agar *Listeria* according to Ottaviani and Agosti (ALOA, Biolife) and Oxford agar (Biolife). After an incubation period of 24-48 h at 37°C, the selective agar plates were examined for the presence of the characteristic colonies that are presumed to be *L. monocytogenes*. Typical colonies of *L. monocytogenes* on ALOA agar are green-blue surrounded by an opaque halo. Suspicious colonies on ALOA agar were Gram stained, tested for hemolysis, motility and catalase activity followed by biochemical identification with the API *Listeria* system (BioMérieux, Mancy l'Etoile, France).

Statistical analysis

Statistical analyses were performed on log-10 transformed data. The probability level at which statistical analyses were accepted as significant was < 0.05. Data were analyzed (means, standard deviations, Student's *t* test) using the software Microsoft Office Excel 2010.

RESULTS AND DISCUSSION

In silver bream the level of TBC and *Enterobacteriaceae* was the highest (7.57 and 4.91 log_{10} CFU cm^{-2}, respectively), while the lowest TBC was detected in round gobby (6.31 log_{10} CFU cm^{-2}), but the lowest *Enterobacteriaceae* in roach (3.68 log_{10} CFU cm^{-2}). While all of the freshwater fish samples were below the limit of *E. coli* enumeration (< 1 log_{10} CFU cm^{-2})**,** *E. coli* was found to be present in all round gobby samples. The number of *E. coli* count in round gobby ranged from 1.11 to 1.72 log_{10} CFU cm^{-2}. The mean values for TBC, *Enterobacteriaceae* and *E. coli* count for fish samples are given in Table 1.

Table 1

Total bacterial count, *Enterobacteriaceae* and *E. coli* in fish at retail market in Latvia

Sample	Number of samples	Total bacterial count $\log_{10}$ CFU cm^{-2}		*Enterobacteriaceae* $\log_{10}$ CFU cm^{-2}		*E. coli* $\log_{10}$ CFU cm^{-2}	
		mean ± SD	range	mean ± SD	range	mean ± SD	range
Roach (*Rutilus rutilus*)	4	6.86 ± 0.85	5.58-7.30	3.68 ± 1.03	2.15-4.36	< 1	< 1
Crucian carp (*Carassius carassius*)	5	6.64 ± 1.20	4.58-7.46	4.05 ± 1.20	1.91-4.78	< 1	< 1
European perch (*Perca fluviatilis*)	5	7.13 ± 0.39	6.64-7.52	3.97 ± 0.38	3.51-4.28	< 1	< 1
Silver bream (*Blicca bjoerkna*)	3	7.57* ± 0.37	7.15-7.84	4.91 ± 0.29	4.57-5.11	< 1	< 1
Round gobby (*Neogobius melanostomus*)	3	6.31* ± 0.46	5.84-6.76	4.86 ± 0.56	4.23-5.28	1.44 ± 0.31	1.11-1.72

* Differences of total bacterial count between silver bream and round gobby were significant ($p<0.05$)

Total bacterial count in silver bream (7.57 $\log_{10}$ CFU cm^{-2}) were considerably higher ($p<0.05$) than in round gobby (6.31 $\log_{10}$ CFU cm^{-2}). Counts of *Enterobacteriaceae* were variable, but no significantly different ($p>0.05$) between fish species. In the present study TBC and *Enterobacteriaceae* count of all raw fish samples was higher than the results of other authors. Increased numbers of *Enterobacteriaceae* and TBC can be linked to unsatisfactory storage and handing conditions at retail market. Total bacterial count was reported lower in pond raised fresh fish in Gelman et al. [22] study on silver perch (*Bidyanus bidyanus*, 1.70 $\log_{10}$ CFU cm^{-2}) and in Acuff *et al.* [23] study on tilapia (*Tilapia aurea*, 2.86 $\log_{10}$ CFU cm^{-2}). *Enterobacteriaceae* count was found to be lower (1.16 $\log_{10}$ CFU g^{-1}) on sea bream stored in ice [24]. *E. coli* possibly indicates to fecal contamination and the presence of enteric pathogens. The occurrence of *E. coli* in raw fish is related to water contamination or poor hygienic conditions during the fish handling.

Table 2

Occurrence of *Listeria monocytogenes* and *Salmonella* in raw fish from retail market in Riga, Latvia

Sample	Number of samples	Number of positive samples (%)	
		Listeria monocytogenes	*Salmonella*
Roach (*Rutilus rutilus*)	4	2	0
Crucian carp (*Carassius carassius*)	5	3	0
European perch (*Perca fluviatilis*)	5	4	0
Silver bream (*Blicca bjoerkna*)	3	2	0
Round gobby (*Neogobius melanostomus*)	3	0	0
Total	20	11	0

During study 11 of 20 raw fish samples collected from retail market were found to be contaminated with *L. monocytogenes*. Among raw freshwater fish samples, European perch had the highest occurrence of *L. monocytogenes* (4 out of 5 samples), while the roach had the lowest contamination (2 out of 4 samples).

However, no *L. monocytogenes* was found in round gobby. None of the examined fish samples contained *Salmonella*. Results for fish species and pathogens are presented in Table 2.
Our findings regarding *L. monocytogenes* are notably higher than that found in other studies in European region. The reported prevalence of *L. monocytogenes* was 0% in herring fillets of market in Belgium [25], less than 1% in raw fish of market in Northern Greece [26], 13.5% in raw fish from seafood plant in the Nordic countries [15] and 14.6% in rainbow trout (*Onchorynchus mykiss*) from fish farms around Finland [14]. *Listeria* spp. are naturally present in aquatic environment [27], therefore their presence in raw fish may be expected. Results on prevalence of *Salmonella* in our study are similar with Davies *et al.* [16] study on *Salmonella* presence in fresh fish from commercial outlets from Europe. It has been suggested that *Salmonella* is not an indigenous bacterial flora of fish [28], however occasional cases on *Salmonella* presence in fish have been reported [29]. *Salmonella* can be introduced in the aquatic environment through animal and human fecal shedding or sewage pollution [30]. *Listeria* spp. and *Salmonella* may contaminate fish in aquatic environment, during transportation to fish markets and storage.

CONCLUSIONS

Raw fish at retail market in Latvia contain high counts of TBC and *Enterobacteriaceae* among all fish species. *E. coli* was found in all round gobby samples. Although this study suggests the absence of *Salmonella*, however raw fish at retail level was found to be highly contaminated with *L. monocytogenes*, therefore consumers should exclude cross-contamination of food during fish preparation and avoid the consumption of raw fish to prevent foodborne infections. In order to assess the shortcomings of fish microbiological quality, there is a need of further studies among entire fish supply chain, including aquatic environment, transportation and storage of fish.

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THE EFFECT OF SUCCESSFUL ADVICE ON THERMAL BACTERIA COUNT IN DANISH BULK MILK

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Abstract. *At Danish dairies, raw milk is not routinely analysed for thermo-resistant bacteria. Nevertheless, thermo-resistant bacteria are known to create serious problems, especially in cheese production. Since 2010 Arla Foods has screened for thermo-resistant bacteria among all of their milk producers (approx. 3500 farms) regularly and the results have showed high but fluctuating levels of thermo-resistant bacteria in raw milk. The objective of those screening has been to decrease the content of thermo-resistant bacteria in the raw milk without incorporating costly microbiological analyses.*

Every time the screening reveals farms with high count of thermo-resistant bacteria in the bulk milk (>1.000/mL) the farm has been contacted by a local milk quality advisors for telephone advising and most farms with >30.000/mL of thermal-resistant bacteria in the bulk milk has been visited for on farm advising. These contacts have revealed some major deviations, on farm level, from existing recommended management, hygiene practices, technical installations and milk storage.

The results indicate:

- *A higher risk for total bacteria count and for high content of thermo-resistant bacteria in Automatic Milking Systems (AMS) compared to conventional milking.*
- *Significant relationship between high total bacterial count and high thermo-resistant bacteria count.*
- *A majority of the installations had clearly visible bio-film various places such as in the receiver and the milk bulk tank.*
- *Faults in warm water supplies and dosage of detergents and disinfectant were frequently observed.*
- *Thermo-resistant bacteria were reduced from a mean count of 2084 in 2010 to 902 in 2014 after farm visits.*

The results, of those telephone contacts and on farm visits by expert milk quality advice, show that if a milk producer is contacted by a competent advisor it enables the producer to correct vital errors and thereby achieve a major reduction in thermo-resistant bacteria content of the bulk milk.

Key words: *milk quality, advisory service, technical installations, milking equipment.*

ANIMAL PRODUCTION, ANIMAL WELFARE AND PROTECTION OF ANIMAL HEALTH

RECOGNIZING HOW ANIMALS ARE FEELING

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Abstract. *The sustainability of animal production systems depends upon the long-term public acceptance of production methods. Animal welfare is an important component of public acceptance, which depends upon confidence that animals used in food production have a reasonable quality of life. The concept of quality of life includes both protection from suffering (extreme and prolonged negative feelings) and opportunities for positive feelings. Yet feelings are elusive, subjective experiences, presenting animal scientists with a challenge in determining how animals are feeling and, thus, evaluating their quality of life. We are now getting closer to offering valid, practical methods for assessing animal feelings on the farm. Advances in neurobiology have generated an improved understanding of mechanisms underlying affective states such as pain, fear, curiosity and joy. When coupled with an understanding of selective forces shaping adaptive behavioural responses, applied ethologists have a foundation for interpretting outwardly measurable behavioural expressions associated with inner affective states. Detailed descriptions are being made of facial expressions, postures, movements, vocalizations,and other behavioural responses occurring in negative and positive contexts. When quantified and combined in composite scales, such responses allow reliable discrimination between positive and negative contexts and, by inference, experienced feelings.This approach has been used, for example, in validating facial grimace scales for recognizing pain. Analysis of vocalizations, coupled with playback experiments to assess their meaning to listeners, has been used to recognize acoustic features of vocalizations that differ between positive and negative situations. Conditioned place preference and aversion techniques, and cognitive bias assessment methods, are offering insights into mood states associated with optimistic and pessimistic anticipation of the future based on past experience.These methods are now being translated into practical tools for animal welfare assessment; a downloadable facial grimace scale 'app' is already available. For a sustainable future, such developments are urgently needed in the quest to assure the public that animal quality of life is being adequately safeguarded in modern animal agriculture.*

Key words: *Animal welfare, affective states, ethics, sustainability, animal production.*

DIETARY CATION-ANION DIFFENCE (DCAD) OF FORAGE SPECIES IN NORWAY

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Abstract. *The difference between cation and anion concentrations (DCAD) is an important property when assessing feed for dry cows in order to avoid hypocalcaemia following calving. Low values of DCAD may reduce the risk of milk fever. DCAD is often calculated as the difference between the cations Na^+ and K^+ and the anions Cl^- and S^{2-}. Research, particularly in Canada, has shown that chlorine fertilization may reduce DCAD, even to negative values, and that there might be differences in DCAD between commonly used grass species. In a research project in Central Norway the effect on DCAD of different rates of chlorine fertilizer application were investigated. Fertilization with 70, 140 or 210 kg Cl^- per hectare in calcium chloride did significantly reduce DCAD in forage from leys dominated by timothy and meadow fescue. Pure stands of seven grass species were fertilized with either 0 or 140 kg Cl^- per hectare in spring. The highest values of DCAD were found in perennial ryegrass and festulolium. Forage with low DCAD was given to dairy cows, and the pH in urine was measured to assess the risk of milk fever.*

Keywords: *anions, cations, DCAD, mineral difference, urine pH.*

INTRODUCTION

Milk fever is the second most common production disease in Norwegian dairy production. About 7% of the calvings in Norway lead to milk fever, which cost more than 50 million NOK. In the sixties Norwegian scientists showed that anions in the feed could reduce the risk of milk fever [1]. Rations with low values of DCAD acidify urine, this acidification hinders calcium reabsorption. Calcium losses through urine activate the homeostatic regulation of calcium by increasing bone mobilization and intestinal absorption [2]. But anionic salts are not very tasty, it may thus be difficult to get the cows to eat the products. The most common formula of DCAD is: $([Na^+]+[K^+]) – ([Cl^-]+[S^{2-}])$ in mEq kg^{-1} DM. The contents of K and Cl are easier to manipulate than the contents of Na and S. To prevent hypocalcaemia, the DCAD in rations fed to non-lactating dairy cows 1-2 weeks before calving should be around -50 mEq kg^{-1} [3]. Research has shown that chlorine fertilization may reduce DCAD, even to negative values, and that there might be differences in DCAD between commonly used grass species [3]. The results indicated an economically optimal rate in the spring between 78 to 123 kg Cl ha^{-1}. The DCAD decreased with advancing stages of development of the grasses. In a research project in Central Norway the effects of chlorine fertiliser application on DCAD in different types of grassland were investigated. Forage from chlorine fertilised meadows were fed to cows the last two weeks before calving, and the urine pH was measured.

MATERIALS AND METHODS

A fertiliser experiment was established in young leys dominated by timothy and meadow fescue at three sites in Central Norway in 2012, with three replicates. The experimental plots (2 m x 7 m) were fertilised with either a ‘normal’ amount of potassium (according to soil analyses) or half the level of ‘normal’. The application of nitrogen and phosphorus in spring was 120 kg and 17 kg per hectare, respectively. At each level of potassium application, the following amounts of chlorine were given as calcium chloride in spring, in three replicates: 0, 70, 140 and 210 kg ha^{-1}. The experiments were harvested in 2012 and 2013. The first cut was taken about two weeks after start of heading of timothy.
A similar field experiment (small plots, three replicates) was established in Central Norway in 2013. Instead of four levels of chlorine fertilization, the treatments were: 0 kg Cl, 140 kg Cl ha^{-1} in either calcium chloride or magnesium chloride and 280 kg in calcium chloride. The levels of potassium were either ‘normal’ (according to soil analyses) or 2/3 of ‘normal’ amount of potassium. This experiment was harvested in two years.

On two experiments established on two year old leys, dominated by timothy and meadow fescue, 14 kg Cl ha^{-1} in calcium chloride was applied either at normal time in spring, or one or two weeks after normal time (small plots, three replicates). The experiments were harvested only one year.

In another type of experiment pure stands of seven grass species were established at three sites in 2012, and fertilised and harvested in 2013 and 2014. The species were: Timothy (*Phleum pratense* L.), meadow fescue (*Festuca pratensis* L.), cocksfoot (*Dactylis glomerata* L.), smooth bromegrass (*Bromus inermis* Leyss.), reed canary grass (*Phalaris arundinacea* L.), perennial ryegrass (*Lolium perenne* L.) and festulolium (*Festulolium*). The plots were fertilised with either zero or 140 kg Cl in calcium chloride in spring on main plots. The grasses were seeded on small plots, with two replicated. The first cut was harvested about two weeks after start of heading of timothy for all species, except smooth bromegrass and reed canary grass, which were cut one week later.

Grass samples from all experiments were analysed for content of minerals. Dietary cation-anion difference (DCAD), as mEq kg^{-1} DM, was calculated according to the following equation: ((Na/22.9+K/39.1) – (Cl/35.5+S x 2/32.07))*1000. The contents of Na, K, Cl and S are given in g kg^{-1} DM. Feed quality was estimated by NIRS in one replicate in 2012 and 2013.

In 2012 and 2013 mini silage bales were produced at the first cut from four different meadows, three of them were 1-2 years old dominated by timothy and meadow fescue. And one meadow was older, with also other grasses. The meadows were fertilised in spring with about 140 kg ha^{-1} Cl in chloride. The silage was fed to the cows, and urine pH was measured. Cows that did not get urine pH below 7 were given concentrate rich in anions.

Data from the fertiliser experiments (means for three replicates within year and site) were analysed according to an ANOVA with a split-plot design. The fixed factor potassium fertilization rate was on main plots and the fixed factor chlorine application rate on sub-plots. Year (1 and 2) and site (1, 2 and 3) were included as random factors in the model. For the trials comparing different species, means for two replicates within each of three sites in one experimental year were subjected to ANOVA. These data were also analysed as a split-plot, with chlorine application rate on main plots and grass species on sub plots. Site was included in the model as a random effect.

Table 1

Dietary cation-anion difference (DCAD), content of minerals and dry matter yield at first cut. Effects of chlorine and potassium fertilisation on leys dominated by timothy and meadow fescue. Average of three field trials in two years.

K fert.	Cl fertilisation	DM yield t ha^{-1}	DCAD mEq kg^{-1} DM	K g kg^{-1} DM	Na g kg^{-1} DM	Cl g kg^{-1} DM	S g kg^{-1} DM
Low	0	7.3	151	16.7	0.51	7.5	1.4
	70 kg Cl ha^{-1}	7.3	83	18.2	0.74	11.6	1.4
	140 kg Cl ha^{-1}	7.1	52	18.9	0.72	13.4	1.3
	210 kg Cl ha^{-1}	7.2	43	18.4	0.78	13.3	1.4
Normal	0	7.2	134	19.3	0.48	10.5	1.4
	70 kg Cl ha^{-1}	7.1	110	21.6	0.64	13.5	1.4
	140 kg Cl ha^{-1}	7.3	81	21.2	0.46	14.1	1.4
	210 kg Cl ha^{-1}	6.9	64	21.7	0.48	15.0	1.4
P potassium fertilisation		ns	ns	ns	ns	0.01	ns
P chlorine fertilisation		ns	0.00	0.05	ns	0.00	ns
P Cl fert. * K fert.		ns	ns	ns	ns	ns	ns

RESULTS AND DISCUSSION

Application of potassium and calcium chloride did not affect the dry matter yield in the fertilisation experiments (Table 1). The DCAD and the contents of K, Na and S were not significantly influenced by the level of potassium fertilisation. Application of chlorine did lower the DCAD, and increased the content of K and Cl. The difference in DCAD between an application of 140 and 210 kg Cl ha^{-1} was not significant. It was expected that a higher application rate of potassium should increase the content of potassium in the plants, but even if the average K content at the low level was 3 g kg ha^{-1} lower than at the normal level, the difference was not significant. Why the chlorine fertilisation affected the content of potassium and why the content of chlorine was influenced by the level of potassium fertilisation is not easy to explain.

There were no significant effects of potassium and chlorine fertilisation on the content of crude protein, water soluble carbohydrates (WSC) and indigestible fibre (iNDF) and feed unit concentration (Table 2). For all treatments the quality parameters were quite low. The differences in fibres (NDF) and organic matter digestibility (OMD) were quite ambiguous, and not easy to explain.

Table 2

Contents of crude protein, fibre (NDF and iNDF) and water soluble carbohydrates (WSC), digestibility of organic matter (OMD) and feed units per kg DM (FU/kg DM) in the first cut. Effects of chlorine and potassium fertilisation on leys dominated by timothy and meadow fescue. Average of three field trials in two years.

K fert.	Cl fertilisation	Crude prot. g/kg DM	NDF g/kg DM	iNDF g/kg NDF	WSC g/kg DM	OMD %	FU/ kg DM
Low	0	113	609	209	111	64	0.78
	70 kg Cl ha^{-1}	124	607	199	101	65	0.75
	140 kg Cl ha^{-1}	100	638	204	112	61	0.70
	210 kg Cl ha^{-1}	105	619	196	107	63	0.77
Normal	0	111	602	202	114	64	0.74
	70 kg Cl ha^{-1}	116	615	218	105	63	0.73
	140 kg Cl ha^{-1}	105	617	218	111	62	0.72
	210 kg Cl ha^{-1}	111	619	212	99	63	0.72
P potassium fertilisation		ns	0.04	ns	ns	ns	ns
P chlorine fertilisation		ns	0.05	ns	ns	0.05	ns
P Cl fert. * K fert.		ns	ns	ns	ns	ns	ns

Table 3

Dietary cation-anion difference (DCAD), content of minerals and dry matter yield at first cut. Effects of calcium chloride, magnesium chloride and potassium fertilisation on leys dominated by timothy and meadow fescue. Average of one field trial in two years.

K fert.	Cl fertilisation	DM yield t ha^{-1}	DCAD mEq kg^{-1} DM	K g kg^{-1} DM	Na g kg^{-1} DM	Cl g kg^{-1} DM	S g kg^{-1} DM
Low	0	6.2	93	7.9	3.5	6.9	1.1
	[1]140 kg Cl ha^{-1}	5.9	-14	7.6	3.2	10.1	1.0
	[2]140 kg Cl ha^{-1}	6.1	24	8.1	3.9	10.0	1.1
	[1]280 kg Cl ha^{-1}	5.5	6	8.0	4.8	11.8	1.2
Normal	0	7.1	90	11.3	3.0	9.2	1.1
	[1]140 kg Cl ha^{-1}	6.7	39	12.0	3.4	12.3	1.1
	[2]140 kg Cl ha^{-1}	6.6	33	11.8	3.2	12.2	1.0
	[1]280 kg Cl ha^{-1}	6.3	6	11.0	3.1	12.4	1.0
P potassium fertilisation		0.00	0.00	0.00	0.00	0.00	ns
P chlorine fertilisation		ns	0.00	ns	0.06	0.00	ns
P Cl fert. * K fert.		ns	ns	ns	0.03	ns	ns

[1]calcium chloride [2]magnesium chloride

Yield, DCAD and content of minerals for the field trial with another experimental plan than the trials presented in Table 1 are shown in Table 3. The DM yield was significantly larger at plots with a normal level of K application compared to a low level of K. But the DM yield was not influenced by either the amount or the type of chloride fertiliser. At the low level of potassium fertilisation low and even negative values of DCAD were obtained. The content of potassium was low, and was significantly higher at the normal level than at the low level of potassium fertilisation. The content of sodium was much higher than in the other experiments. There was no effect of chloride type on DCAD. Fertilisation with 280 kg Cl ha^{-1} did not decrease DCAD compared to 140 kg Cl.

On two experiments the application of 14 kg Cl ha^{-1} in calcium chloride was delayed one or two weeks after normal time. The postponed fertilisation did not significantly affect either the DCAD or the content of minerals.

There were significant differences in DCAD between the species, but there were no effects of chlorine fertilisation on DCAD in the different species on average of three field trials in the first year (Table 4). Without chlorine application the DCAD varied from 180 in reed canary grass to 347 in cocksfoot. When chlorine was applied the DCAD was about 150 in meadow fescue, cocksfoot and smooth bromegrass. The lowest values were found in perennial ryegrass (69) and reed canary grass (36). In the second year the contents of minerals were analysed only for the treatment with 140 kg Cl ha^{-1}. The differences in DCAD between the species were about similar to the first year. The grasses timothy, meadow fescue, cocksfoot and smooth brome grass had a DCAD of about 115. The values of perennial ryegrass, festulolium and reed canary grass were 83, 74 and 48, respectively. The differences in DCAD between species may partly be explained by differences in DM yield and time of heading in the first cut.

Table 4

Dietary cation-anion difference (DCAD), content of minerals and dry matter yield at first cut. Effects of chlorine fertilisation on different species. Average of three field trials in one year.

Cl fert.		DM yield t ha^{-1}	DCAD mEq kg^{-1} DM	K g kg^{-1} DM	Na g kg^{-1} DM	Cl g kg^{-1} DM	S g kg^{-1} DM
No Cl fert.	Timothy	7.2	235	19.3	0.15	6.8	1.2
	Mead. fescue	6.5	229	23.1	0.27	9.9	1.6
	Cocksfoot	5.9	347	23.9	0.88	7.8	1.5
	S. bromegrass	7.4	213	16.8	0.27	5.8	1.1
	Reed c. grass	6.4	180	19.4	0.20	8.1	1.4
	P. ryegrass	6.2	268	21.1	1.58	8.9	1.6
	Festulolium	6.4	312	25.2	1.10	9.1	1.7
140 kg Cl ha^{-1}	Timothy	7.0	110	19.9	0.17	12.3	1.1
	Mead. fescue	6.7	154	24.6	0.22	14.4	1.6
	Cocksfoot	5.4	156	28.0	1.15	18.3	1.5
	S. bromegrass	7.0	154	18.7	0.20	10.1	1.1
	Reed c. grass	6.9	36	20.4	0.28	13.9	1.5
	P. ryegrass	6.5	69	23.6	2.25	19.6	1.6
	Festulolium	6.6	119	27.2	0.95	17.7	1.6
P chlorine fertilisation		ns	ns	ns	ns	ns	ns
P species		ns	0.00	0.00	0.00	0.00	0.00
P chlorine fert. * species		ns	ns	ns	ns	0.00	ns

The forage quality presented in Table 5 relates to the second half of Table 4 (140 kg Cl ha^{-1}). Because of a rather late first cut the quality of most species were quite low. An optimal feed unit concentration for non-lactating cows some weeks prior to calving is probably 0.75-0.80. In reed canary grass, which had the lowest DCAD (Table 4) the feed unit concentration was as low as 0.66 at the actual stage of development. And that is too low for dairy cow forage. Perennial ryegrass had a DCAD of 69 and feed unit concentration of 0.80.

Table 5

Contents of crude protein, fibre (NDF and iNDF) and water soluble carbohydrates (WSC), digestibility of organic matter (OMD) and feed units per kg DM (FU/kg DM) in the first cut for seven grass species. Average of three field trials in the first year.

Cl fert.		Crude prot. g/kg DM	NDF g/kg DM	iNDF g/kg NDF	WSC g/kg DM	OMD %	FU/ kg DM
140 kg Cl ha^{-1}	Timothy	85	590	227	110	62	0.71
	Mead. fescue	118	583	184	116	67	0.78
	Cocksfoot	102	625	224	91	62	0.70
	S. bromegrass	84	564	242	192	63	0.72
	Reed c. grass	91	623	287	106	59	0.66
	P. ryegrass	97	548	175	153	70	0.80
	Festulolium	110	598	173	107	65	0.74
P species		0.03	0.00	0.00	0.00	0.00	0.00

As shown in Table 6 the DCAD in the mini bales was higher in 2012 (157) than in 2013 (17-57), probably because the meadow sampled in 2012 was a first year ley and fertilized with cow manure rich in potassium. With the 2013-harvested roughage 15 out of 21 cows had successfully urine pH below 7, no anion-supplement was necessary. The remaining 6 cows also got urine pH below 7 with supplementation with an anion-rich concentrate. Roughage with low DCAD, not necessarily negative, did successfully lower urine pH to milk fever preventive values.

Table 6

Effect of forage with different dietary cation-anion difference (DCAD) on urine pH of 33 cows in two years. Number of cows with milk fever preventive urine pH-values (6-7) and unsuccessful urine pH-values (>7); without or with anion-rich concentrate.

Year	**2012**	**2013**		
DCAD (mEq./kg DM	157	17	22	57
No. of cows				
Cows with urine pH 6-7, without anion conc.	0	7	5	3
Cows with urine pH 6-7, with anion conc.	8	2	0	4
Cows with urine pH > 7 with anion conc.	4	0	0	0

CONCLUSIONS

Chlorine fertilisation with approximately 140 kg ha^{-1} Cl decreased DCAD in forage significantly to a level suitable for feeding dry cows prior to calving. Although there were differences in DCAD between species, it may be difficult to achieve a sufficient low DCAD by only selecting species with a low DCAD. By analysing pH in urine from cows fed with forage with a low DCAD it was indicated that the risk of milk fever was reduced.

ACKNOWLEDGEMENTS

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EFFECT OF ORGANIC AND CONVENTIONAL HOUSING ON PREVALENCE OF OSTEOCHONDROSIS DISSECANS IN FINISHING PIGS

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Abstract. *For more than a decade organic fattening pigs in Sweden have had 3 to 5 times higher joint condemnation rates at slaughter than conventional pigs [1]. Osteochondrosis dissecans (OCD), characterized by cracks in the epiphyseal articular cartilage and synovitis, is a main cause of joint condemnations in Swedish organic fatteners [2]. Organic fatteners range freely indoors and have access to an outdoor paddock and/or pasture, while conventional fatteners mostly are confined to small indoor pens. We hypothesized that free-ranging promotes development of OCD. This study compared the prevalence of OCD in shoulder, elbow, stifle and hock joints of 91 free range and 45 confined crossbred Hampshire (Yorkshire x Landrace) fatteners, originating from the same piglet-producing herd.*

One thousand and eighty-eight joints were examined. In 45% of the free-range, compared to 17% of the confined pigs, an OCD lesion was present in at least one joint. OCD lesions occurred in the free-range in 9 of 18 examined locations and in the confined in 3 locations. The confined pigs had no OCD lesions in the shoulder or the stifle, the free range had 2.4% in the shoulder and 3.2% in the stifle. In the elbow 15% of the free-range pigs compared to 5% of the confined had OCD. In the hock 38% of the free-range compared to 14% of the confined pigs had OCD lesions. The difference in OCD prevalence between the free-range and the confined pigs was significant (p<0.01) in the hock and for the whole pigs.

The study indicates that free-range housing increases the risk fatteners have of developing OCD. Increased impact/stress on joints due to free-range activity may be the mechanism behind this. OCD may cause lameness and affect welfare in pigs, suggesting breeds better adapted to an active life may be needed for more sustainable organic pig farming. The study was conducted at one farm and the differences in housing environment were many. Hence, more research is needed to verify these results and to examine whether also other factors influence the pathogenesis of OCD in free range pigs.

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ECONOMIC ASPECTS OF IMMUNOCASTRATION IN THE PIGS

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Abstract. *In modern pork production, male pigs are usually castrated because intact boars can develop boar taint in the meat. Castration is considered as a measure which detoriates animal welfare. The goal of this study was to develop a model which can be used to estimate the costs and benefits of switching from the current castration practice to immunocastration. In the baseline scenario immunocastration was estimated to reduce the profits of the supply chain a little. However, the result was sensitive to several factors. In conclusion, economic incentives to adopt immunocastration depend on the production technology that is available and on meat procurement policy. Hence, coordination between farms and meat buyers is needed.*

Key words: *Pigs, castration, immunocastration, boar taint, production costs.*

INTRODUCTION

In modern pork production, male pigs are usually castrated because intact boars can develop boar taint in the meat. Castration is considered as a measure which detoriates animal welfare as it causes pain and inflammation in the animal. It is therefore criticized as a production practice and a group of stakeholders have agreed to cease traditional castration in Europe by year 2018.

Boar taint is a characteristic undesired by the consumer. It is penetrating unpleasant odour and accompanying taste in pork which is developed before animals reach their conventional slaughter weight. If strong, it is associated with manure, urine and sweat. A person can only smell the odour when the meat is heated. The majority of a pig is destined for the fresh meat market, and hence the meat will be heated during the food preparation. The sensitivity of consumers to boar taint varies by country. A pan-European study suggests that a considerable proportion of consumers sense boar taint and dislike it, and the occurrence of boar taint in the meat can reduce their pork consumption.

Alternatives to traditional castration of male pigs have been presented. The alternatives include slaughtering the boars before the taint develops (i.e. at a lower weight) or immunocastration. Studies suggest that the consumers are indifferent between meat from castrated pigs and meat from boars that did pass the boar taint detection test at the slaughter line. Immunocastration is a procedure in which the young male pigs vaccinated against boar taint. The vaccine binds to pig's own circulating GnrH inactivating it, this determines the reduction of androstenone production in the testicles. The outcome is reduction of testicle growth and absence of boar taint in the meat.

One of the challenges in implementing immunocastration is that it may increase operating costs throughout the supply chain. Additional costs may be incurred at pig finishing farm, animal transportation and slaughterhouse. Hence, it isn't just a single pig farm that is affected, but there may be also other businesses which can benefit or suffer economic losses from immunocastration.

Until now, studies have examined economics of alternative castration methods mainly as a farm-level problem. However, there several stakeholders which castration method used by a farrowing farm can affect, and therefore it should be examined by taking into account the views of these stakeholders.

The goal of this study was to develop a model which can be used to estimate the costs and benefits of switching from the current castration practice to immunocastration. This study contributes to the literature by examining the issue from the viewpoint of several stakeholders. We analyze economic incentives of stakeholders to apply immunocastration under different scenarios regarding logistical organization of the supply chain, slaughterhouse meat pricing scheme, and farm type.

MATERIALS AND METHODS

The data were biological data from an animal experiment conducted at an experimental farm in Finland and economic data retrieved from statistics. A value chain simulation model was developed to assess the financial impacts of alternative castration practices. The model had three stakeholders: a piglet producer, a finishing farm and a slaughterhouse buying the pigs. Each stakeholder was assumed to maximize their gross margin (revenues minus variable costs, assuming that the investments on production capacity have already been made).

RESULTS AND DISCUSSION

In the baseline scenario immunocastration was estimated to reduce the profits of the supply chain. However, the net effects were quite small as the total extra costs were estimated approximately at €1 per metric ton of pigmeat from male pigs.

Analysis of varius scenarios illustrated that the results were sensitive to a number of variables. Although immunocastrated pigs produced leaner meat and they were more efficient in producing meat at a finishing farm, additional costs due to immunocastration were incurred both at the finishing stage and along the supply chain. Moreover, savings in the costs of avoiding traditional castration were only marginal.

In the baseline scenario the slaughterhouse paid the same price for both castrated and immunocastrated pigs, immunocastrated pigs' logistics were separated from female pigs and the slaughterhouse hired extra staff designated to handle and inspect immunocastrated pigs.

The results suggest that the integration of the supply chain is vital to the adoption of immunocastration as a production practice. Two factors appear to be of special importance. First, currently major slaughterhouses in Finland pay a significantly reduced price for boars' meat, including meat from immunocastrated boars. The results suggest that for farms to have economic incentives to start widespread use of immunocastration requires that a slaughterhouse adjusts pricing scheme so that all immunocastrated pigs (including those which vaccination might be unsuccessful) would be procured according to the same price list as castrated male pigs. Second, if the rearing of male and female pigs must be separated to benefit from immunocastration, then the production units should be large enough to avoid unnecessary costs or have suitable production technology in place. The results suggest that immunocastration would be best suited to farrowing-to-finishing operations or to large nearby specialized farms which have integrated their operations e.g. through contracting, or to large farms which have feeding technology capable for differentiating feed supply by compartments. Given that the meat is producer at regular price, in these cases immunocastration could provide additional value-added of approximately €21 per metric ton of pigmeat.

CONCLUSIONS

In conclusion, economic incentives to adopt immunocastration depend on the production technology that is available and on meat procurement policy. Hence, coordination between farms and meat buyers is needed. It could be an opportunity also for a niche market company. If these issues can be solved, immunocastration is economically more attractive option that the use of reduced slaughter weight.

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DEVELOPING LIVESTOCK VACCINES – CAN A REAL OPTIONS APPROACH TO COST ASSESSMENT MAKE A POLICY DIFFERENCE?

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Abstract. *Reduction of animal disease and zoonotic health risks provides a range of benefits to society. Realizing these benefits requires increased focus on infection treatment and prevention and development of new cost-effective surveillance, monitoring and control measures. One avenue of prevention strategy is to accelerate the use of animal vaccines to a broader range of infectious animal diseases. Vaccines are often epidemiologically effective control measures, although there may be missing or rather low economic incentives for the development of new animal vaccines, due to high costs and considerable technological and economic uncertainty. The veterinary pharmaceutical industry is reluctant to share information about their specific development costs, but some studies indicate rather significant costs associated with vaccine development, with fixed costs representing a very large component of these costs. The high degree of uncertainty associated with the development of new vaccines however also creates a number of options in the different development phases, and the potential economic value of these options might be assessed by the real options approach and incorporated in the cost-benefit assessment of a vaccine development project.*

The aim of this study is to identify and analyze public-private incentives for the development and marketing of new animal vaccines within a real options methodological framework, and to investigate how real options methodology can be utilized to support economic incentives for such vaccine development in a cost-effective way. We have used the development of a vaccine against Campylobacter in poultry as a case study.

An economic model was constructed to represent the staged investment decisions during a vaccine development process comprising research and development (R&D), patenting, testing, documentation and approval, and market launch in a Net Present Value calculation. The model enables cost assessment in alternative settings, where different options can be included or excluded. In particular, we used the model to compare a purely probabilistic setting with a setting with abandonment options, and with a setting with both abandonment and sales options at different stages of the project.

Employing the real options methodology, the net present value of the vaccine R&D project becomes larger than a purely probabilistic expected present value throughout the stages of the project – and the net present value becomes larger, when more types of real options are taken into consideration. The insights from these analyses reveal opportunities for new policies to promote the development of animal vaccines. One such approach might be to develop schemes combining stage-by-stage optimized subsidies in the individual development stages, with proper account taken of investors'/developers' economic incentives to proceed, sell or cancel the project in the respective stages. Another way of using the real options approach to support the development of desirable animal vaccines could be to issue put options for the vaccine candidate, enabling vaccine developers to hedge against the economic risk from market volatility.

Even if an effective Campylobacter vaccine is developed, there are still some challenges to be met. Farmers are assumed to be driven mainly by profitability when deciding whether or not to vaccinate their herds, and they have relatively little economic capacity to take up the extra cost of vaccinating the birds, unless they are compensated by obtaining a higher price upon delivery to slaughtering.

Due to the limited public availability of cost data on vaccine development and production, the empirical foundation for the economic model is relatively weak. Nevertheless, the real options calculations are fairly robust to these assumptions. Future improvements are however needed to make real options methodologies an effective tool for the assessment and design of biotechnology investment policies – including a closer cooperation with the industry in order to obtain better empirical cost and probability data.

Key words: *Real options, veterinary vaccine, research and development investment.*

ECONOMIC EVALUATION OF AN ERADICATION PROGRAM OF VIRULENT FOOTROT IN NORWEGIAN SHEEP

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Abstract. *In 2008 virulent footrot was detected in Rogaland, a county in south-west Norway. This first known outbreak since 1948 was linked to import of live sheep from Denmark in 2005 (Gilhuus et al., 2014). Footrot is caused by* Dichelobacter nodosus, *were the virulent strains may cause severe disease with large impact on animal welfare and production. An eradication program, "Healthy feet", financed by the agricultural agreement scheme and marketing fees, was initiated (Vatn et al., 2012). A corps of especially trained inspectors, supported by field veterinarians and farmers, carried out more than 6000 flock examinations. A substantial proportion of the infected sheep were located at the island Rennesøy. In total 130 flocks fulfilled sanitation including ten flocks infected with benign strains that had severe disease symptoms. In 64 flocks all animals were culled while medical sanitation, involving footbaths of animals with limited symptoms and culling of animals with severe symptoms, was performed in the remaining flocks. More than 4000 sheep were culled. Footrot is a notifiable disease, and several restrictions, such as prohibition of trade in living animals and dispatching animals to common pastures, were imposed on infected flocks. The program ended in 2014 and is followed by surveillance and control by the Norwegian Food Safety Authority from 2015. The purpose of the study is to investigate the economics of the program to Norwegian farmers and the sheep industry.*

A simulation model has been developed to portray a likely geographical spread of footrot without the eradication program but assuming farmers undertake some measures themselves (Grøneng et al., 2015). The model is based on probabilities for spreading footrot among farms within each county, mainly depending on climatic factors and distance between sheep farms. The model calculates likely spread of the disease across county borders through transport of sheep and cattle and use of common pastures. Use of common mountain pastures creates a risk of direct contagion in about 100 days annually, mostly during the gathering process in the end of the season. Outdoor feeding on pastures in the winter and use of improved local pastures in the summer increases the risk. The disease may also spread through common breeding operations like "ram circles", animal exhibitions and selection shows while a strict limitation on trade of sheep from one county to another slows the spread. The model was parameterized with data in national databases, literature and data from the eradication program.

Footrot is well known in Europe and in the UK 86% of the sheep farms reported footrot (Wassink et al., 2003). The most likely scenario, in which the number of infected flocks in Norway increases from 0.1% to 52.6% in 25 years, was selected to calculate the Net Present Value (NPV) of the eradication program. The inflation adjusted eradication costs, including associated costs and losses by the sheep holders, insurance companies, and the Food Safety Authority, aggregated to nearly NOK 70 million. The main benefits of the program consist in avoided production losses and saved costs on treatments and control of the disease. Control measures, such as footbaths and trimmings, may be expensive and laborious. Footrot may result in lameness, however, animal welfare effects have not been assessed. The accumulated NPV was positive after approximately twelve years after start of the program in a main alternative with production losses set to 1% in affected herds or by using the 30% effects on production and reproduction in affected sheep as assessed by Nieuwhof and Bishop (2005). Using their low assessment of 6.7% resulted in positive NPV after 17 years. The results are in agreement with those of Carmody et al., (1984) who reported positive NPV and benefit-cost ratios for a footrot eradication scheme in the New England region of New South Wales in Australia.

Key words: *sheep, net present value, Norway, eradication program, ovine footrot.*

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RESOLVING FOLLICLE POPULATIONS WITHOUT BIOPSY – ENHANCING OPTICAL FIBRE DIAMETER ANALYSIS OF WOOL AND FUR QUALITY

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Abstract. *The coats of mammals contain fibres from three different types of follicles in varying proportions. The quality and performance of wool and fur products is critically dependent on exactly how these three classes of fibre interact with each other, especially in the various Northern European Short-Tail sheep breeds. Follicle populations are normally determined by making microscopic studies on skin biopsy samples. However, modern, computerised optical equipment and methods give quick and easy statistics on fibre diameter (FD) distributions. The aim of this study is to determine if the distribution of follicle types can be extracted directly from these statistics, with particular reference to the needs of the Swedish Northern European Short-tail (NEST) sheep industry. Our work shows that FD data on fleece samples from three different Swedish NEST breeds can indeed be processed to yield their S/P ratio directly without resorting to skin biopsy, and suggests that this may in many cases also be possible even with single-coated breeds such as Merino. During this work we have made surprising discoveries especially concerning the Gotland pelt sheep, where we see that each follicle type produces its own specific proportion of black and white fibres. We also see that the ratio of secondaries to primaries (S/P ratio) that is typically about 2 in most NEST breeds, has been reduced to only 0,06 during subjective Gotland breeding for good curl structure. Our continued research involves a nation-wide optical FD inventory of the fleece of over a thousand Swedish Finewool sheep, and continued exploration of the possibilities and limitations of optical FD analysis for Northern European Short-Tail sheep and other fur animals in which the balance between primary and secondary fibres is important.*

Key words: *OFDA, distribution, primaries, secondaries, pigmentation.*

INTRODUCTION

Optical fibre diameter (FD) analysis was originally developed to meet the needs of the Merino and Mohair industries. The OFDA 100, is unique in its capacity to include measurements on kemps and pigmented fibres. However, since either of these fibre types is a sufficient indication for Merino or Mohair individuals to be culled, the programmers have not endeavoured to distinguish them in more detail.

Northern European Short-tail (NEST) is a group of hardy sheep breeds spread through the Scandinavian countries. A comprehensive (but incomplete) list of NEST breeds is available on Wikipedia [1]. Some NEST breed descriptions include both kemps and pigmented fibres, so that breeders need to measure them separately. Moreover, NEST breeds are basically double-coated; knowledge of the ratio of secondary to primary follicles (S/P ratio) is desirable but has not been available from optical FD analysis. S/P is normally determined by skin biopsy which demands considerably more time and resources than procuring a fibre sample [2].

The aim of this study is to investigate if it is possible to extend the processing of optical FD data, originally developed for Merino and Mohair, to meet these specific needs of the Swedish NEST industry.

Swedish short-tail breeds are often collectively termed as Swedish Landraces to distinguish them from imported non-NEST breeds. They are grown between north latitudes 55° N and 67° N, mostly on natural grazing, some of it in forestry. They are housed and fed hay and supplements during the winter, when grass growth has ceased. Fertility is often high with twins and triplets being the norm. Together with early sexual maturity, this means that skilled and determined breeding can make fast progress. Each breed is customarily coupled to specific fibre products and textile craft techniques. Breeders who can fulfil these special demands on fleece properties gain extra income from their flocks. This entails determined selective breeding, traditionally based on subjective judgement skills. This paper seeks to demonstrate that objective optical FD analysis can simplify landrace breeding selection in the three breeds selected below.

Gotland (Swedish Pelt Sheep) are bred to produce short-cut lustrous silvery lambskins with a specific style of distinctive curls. In sheep, curl or fibre crimp is produced in a periodic rhythm ranging from seven days in Merinos to over three weeks in Gotlands. Crimp size depends on the length of fibre produced during each rhythm period[3][4]. Growth rate typically correlates with fibre diameter, so coarser fibres have longer crimp waves with larger curl radius. In the Gotland with its double-coated NEST origin, secondary fibres are finer and therefore have smaller crimp radius than primary fibres. If the curvature spread within each follicle type is too wide, the fibres do not match each other and they will not find their way back into the same neat curl structure after being disturbed - such skins will not retain their typical Gotland appearance. Breeders must also aim for a primary FD around 45 μm to give robustly springy fibres, while seeking to maximise lustre and to match a specific shade of grey. Breeders need to master the simultaneous evaluation of all these traits, together with low hide weight and high meat production. [5].

Swedish Finewool or Finull is closely related to Finnsheep and shares its extreme fertility, even in meat breed crosses. However, while Finnsheep breeding has been striving to achieve both softness and robust pelts simultaneously, in Sweden the successful Gotland breed specialisation in pelts has left the Finewool free for over eighty years to concentrate on breeding specifically for lustrous softness. [6].

Rya is a Swedish long-primary NEST resembling the Spelsau, Icelandic and others. However, the Rya differs from these in that it has been specifically bred to eliminate kemps in accordance with the demands of Swedish textile handicraft traditions. [7].

MATERIALS AND METHODS

Optical fibre diameter analysis with an OFDA 100 became available in Sweden in the province of Jämtland in 2007 as part of the regional EU project Ull-Rika, a feasibility study for the re-introduction of Merino sheep to Sweden to supply the local cold-climate underwear industry. Analysis services are now available nation-wide by post (UllFORuM, Torsta AB, Ösavägen 20, SE 836 94 Ås, Sweden), with discounts to breed societies.

Wool samples. Since this study is intended to explore possibilities rather than generate statistics, the wool samples used in this study are not random samples, but have been deliberately chosen to explore the variations present in the Swedish short-tail population. Samples are from UllFORuM's routine production runs, from breed societies [5]-[7] and from an innovative sheep cooperative seeking to re-introduce grazing of mountain pasture [8].

Wool fibre measurements. The wool samples were analysed using the optical FD analyser (OFDA100; BSC Electronics Pty Ltd, Western Australia, Australia). The OFDA 100 is the only optical fibre diameter (FD) analyser that can also measure opacity (in %), fibre curvature (in °/mm) and surface roughness (in three size categories). All samples were manually aqueous scoured in accordance with the procedure specified in 2008 by OFDA's European distributor [9]-[12]. UllFORuM has rationalised this procedure by combining 35 plastic mesh cells into a rack that fits into a plastic container with 30 l of water with 50 ml of detergent (Power Scour from unicornfibre.com). The dried and conditioned fleece is then subsampled using OFDA's guillotine device designed to provide 2mm snippets of wool which are then distributed across a microscope slide by the OFDA rotary sample spreader.

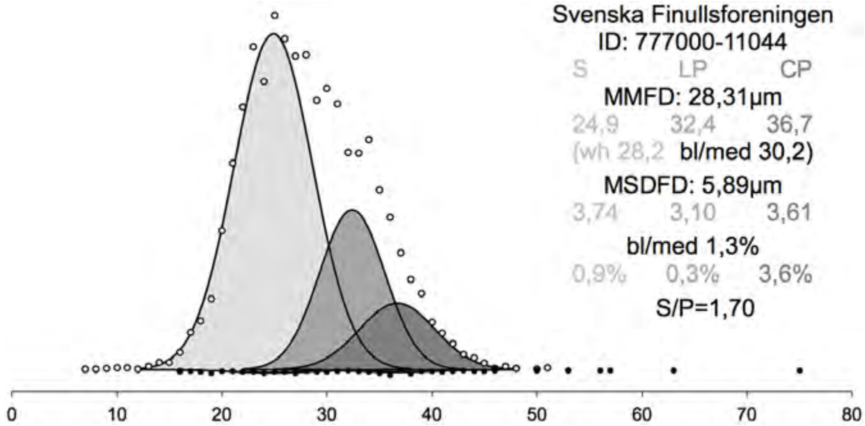
OFDA file types. The OFDA software can generate many types of files with various selections of key parameters. The most complete standard file is the MESFILE (.MES) which sorts fibres into 150 bins from 1 μm to cut-off at 150 μm. OFDA measures several thousand snippets in two minutes, which is about the time required for the operator to prepare the next slide. Bins around the mode may contain several hundred fibres, while bins in the tails of the histogram contain only a few fibres. Here, the shape of the distribution is concealed by stochastic variations which cause problems during analysis. To some extent this can be alleviated by using the High Resolution (.HRS) file format together with the MESFILE. HRS contains a list of 0,1 μm bins from 1 μm with cut-off at 25 μm. If this information is not saved, it is lost as soon as the next sample is scanned, and it cannot be recovered. We strongly advise that OFDA 100 is always set to record both MES and HRS files.

Mathematical analysis. Our first OFDA histograms of NEST fleece samples from Gotland and Rya showed obvious diameter zones that seemed to correspond to secondaries, lateral primaries and central primaries respectively. It seemed likely that the FD distribution could be modelled by superimposing three Normal distributions – if their parameters could be deduced from the data. Most spread-sheet programs deduce the parameters of the single Normal distribution that best models a given data set, but resolving superimposed Normal distributions is more difficult. Not finding any available software to suit our needs, we have developed

our own algorithms in the form of an Excel workbook, as a tool to resolve the necessary parameters from OFDA data on samples from Swedish NEST breeds.
We regret that we are unable to publish our algorithms at this time. However, we can assist other researchers by processing small numbers of their submitted histograms tables (with real or synthesised data) and returning our results.

RESULTS AND DISCUSSION

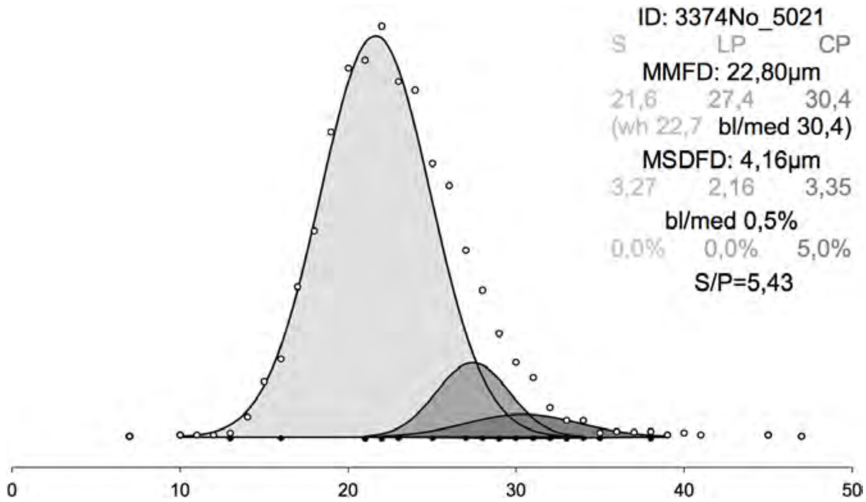
Using our algorithms, we have been able to resolve OFDA histogram data into three superimposed normal distributions, one for each of the three follicle types.
In order to make the following histograms with three follicle types more legible, we have chosen to depict the white fibre distribution upwards (white dots) and black fibre distribution downwards (black dots) rather than superimposing them on each other in the conventional way.
In the following Figures, the populations of secondary, lateral primary and central primary fibres are shown in three darkening shades of grey.



S = secondary, L = Lateral, C = Central, P = primary, MM = measured mean, FD = fibre diameter, MSD = measured standard deviation, bl/med = percentage of black and/or medullated fibres

Figure 1. **A Swedish Finewool histogram resolved into its follicle types**

The ***Swedish Finewool*** breed society [6] is currently running a Ministry of Agriculture financed OFDA inventory of Swedish Finewool fleece samples from 1000 ewes and 100 rams. We plan to do follicle-type analysis on all these samples during 2015, of the type shown in Figure 1.
Experimentally, we have also been able to resolve ***Merino*** samples into follicle types, as shown in Figure 2.

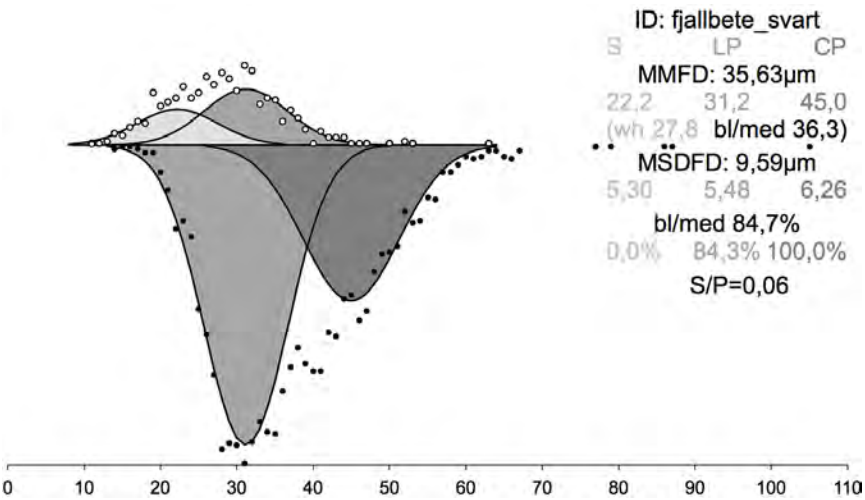


S = secondary, L = Lateral, C = Central, P = primary, MM = measured mean, FD = fibre diameter, MSD = measured standard deviation, bl/med = percentage of black and/or medullated fibres

Figure 2. **A Merino histogram resolved into its follicle types**

More work is needed to establish the exact conditions under which this is or is not possible, including the amount of skewness required, and to establish confidence levels for the parameters obtained. Some of this work needs to be done on animals on which skin biopsy follicle analysis has been performed.

Gotland histograms have been amenable to revealing the proportions between their follicle types as shown here in Figure 3.

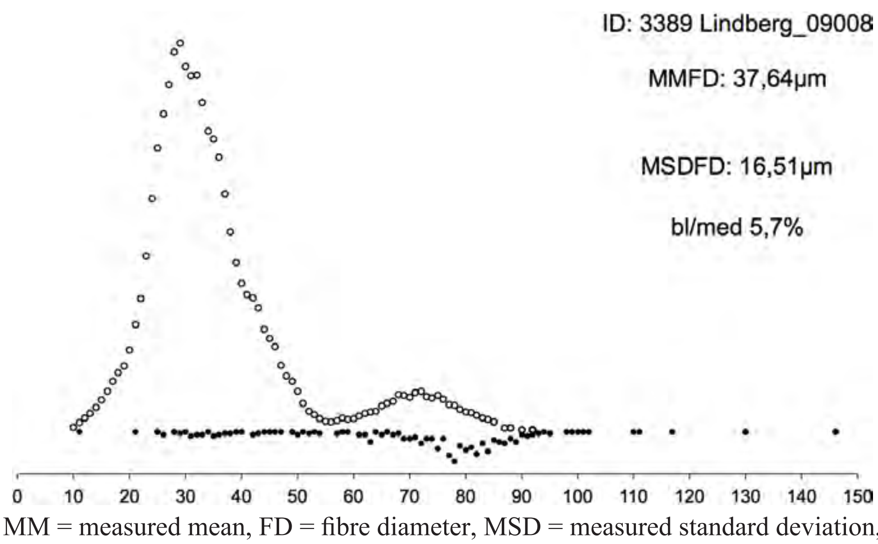


S = secondary, L = Lateral, C = Central, P = primary, MM = measured mean, FD = fibre diameter, MSD = measured standard deviation, bl/med = percentage of black and/or medullated fibres

Figure 3. **A Gotland histogram revealing an exceptionally low S/P ratio of only 0,06**

Gotland skins are grey, but contain no grey fibres; under magnification it is easily seen that they are a mix of black fibres and white fibres. Our histograms reveal them as mixture of three different greys, as in Figure 3. Here, 84,3% of the lateral primaries LP are black throughout their diameter range, while the secondaries S are 0% black and the central primaries CP 100% black. Many other variants occur in the population; another of our Gotland samples shows 0% black LP, 12,6% black S, and 93,7% black CP. If we mate a grey ewe with a ram that has the same apparent shade but quite different distributions, what shade will the lambs have? Follicle resolution may assist grey sheep breeders in selecting parents that are grey for similar reasons, while also making it easier to plan Gotland breeding to continue to eliminate the secondaries.

Samples of classical ***Rya*** fleece are trimodal and easy to analyse into three follicle types.



MM = measured mean, FD = fibre diameter, MSD = measured standard deviation, bl/med = percentage of black and/or medullated fibres, S = secondary, P = primary, L = Lateral, C = Central

Figure 4. **Example of a Rya histogram that refuses to resolve into S, LP and CP**

However, we see many Rya histograms with features that do not match the concept of three superimposed normal distributions, as shown in Figure 4. We see modes with higher or lower kurtosis than normal. We see thicker tails and thinner tails. We see unexpected “swellings” between secondaries and primaries that make us wonder whether suggestions about a fourth primary in camels might also apply to Ryas [2]. However, in the sample material we have at present these effects, although big enough to disturb our algorithms, are not large enough to rise above the stochastic noise level with confidence. There is something going on here, but we do not know what it is. Here, more work is required.
More work is also needed to see if the OFDA 100 can be made to distinguish between fibres that are opaque because they are ***kemps*** (medullated) and fibres that are opaque because they are ***pigmented*** [13].
There are several ***issues*** with the OFDA 100 MESFILE format, and how it causes problems in Excel – contact us to share our experiences and workarounds.

CONCLUSIONS

S/P ratios can be deduced from OFDA data without resorting to skin biopsy techniques. More work will be needed to determine the exact conditions under which this is or is not possible.

Modelling diameter distributions. Fleece fibre population can be modelled by three Normal distributions specified by seven parameters:

Table 1

Fibre Population expressed as three overlapping Normal Distributions

Follicle Type	Mean Fibre Diameter FD	Standard Deviation of FD	Population as function of Secondary/Primary ratio S/P
Secondaries S	FD_S	SD_S	
Lateral Primaries LP	FD_{LP}	SD_{LP}	
Central Primaries CP	FD_{CP}	SD_{CP}	

We suggest that these seven parameters will be more useful for genetic selection work for fleece and fur quality than earlier methods using generic FD and SD augmented by parameters expressing kurtosis and skewness. More work is required to determine the exact conditions necessary to guarantee convergence in the calculations involved, but our algorithms work on all the NEST samples that we have looked at and we have seen that they can also work with Merino samples of sufficient skewness.

Gotland S/P ratios. The subjective selection procedures that have been used to improve curl structure have not led to a better curvature match between primaries and secondaries; instead, they have led to a drastic reduction in the number of secondary fibres, so that modern Gotland pelts have S/P ratios as low as 0,06.

Pigmentation. In Gotland, each follicle type produces its own proportion between white and pigmented fibres. We see similar tendencies in other pigmented NEST breeds such as Spelsau which we have not yet measured. This could imply that genes for grey colour may regulate different follicle types in different ways [13].

Diameter of pigmented fibres. The pigmentation proportion does not change between the thinnest and the thickest fibres within the same follicle type; to a first approximation it appears to be constant. We conclude that, despite the fact that black fibres are black because they have received grains of melanin that are absent in white fibres, it is not to a first approximation possible to see any diameter difference between the white and the black fibres within a single follicle type.

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This study was generously supported by the EU project ullFORuM (now Torsta AB, Ösavägen 20, SE 836 94 Ås, Sweden) who kindly provided lab time on their OFDA equipment and access to their analysis archives. I also wish to thank Svenska Finullsföreningen [6] who provide access to all OFDA data from their current breed-wide study; the Gotland Silver Association [5] and Ryaklubben [7] for pinpointing and donating significant samples; the innovative sheep farm Fjällbete [8] for samples from the most extreme

Gotland Silver I have ever analysed; and to Sonja Thyen for many kitchen-table conversations based on her decades of work as official optical microscopist and wool reviewer to both Ryaklubben and Svenska Finullsföreningen.

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SCANDIVAVIAN HORSE INDUSTRY – FUTURE SCENARIOS AND FORESIGHT ANALYSIS

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Abstract. *As in most industrialized countries, the horse number declined in Norway and Sweden as agriculture and forestry became mechanized. The number of horses was probably at its lowest around 1970. In 2012, there were 362 700 horses in Sweden and 100 000 to 125 000 horses in Norway or 39 horses per 1000 inhabitants in Sweden and 20-25 in Norway. The Swedish figure is high by international comparisons. A few horses are still used in agriculture and forestry, but today most horses are used for other purposes, both commercial and for leisure. The commercial horse sector consists of i.a. trotting and horseracing, riding schools, and boarding activities, and has been regarded as a possible contributor to rural development by the agricultural authorities in both countries.*

Based on a literature review important drivers for supply and demand of horse related services and development of the horse industry were identified. On the demand side, fashion and trends were regarded as important. Trends include population growth and demographic changes, economic liberalization, animal welfare concerns etc. Stochastic incidents, such as the financial crisis in 2008-12, are also of importance. The demand for equine services might be more elastic to changes in income than the demand for other farm products (Bailey et al. 2000). The horse industry could experience a growth if income per capita increases, but also a serious decline in a recession. Costs are important for the supply of horse-related services. Many horse services are labour intensive, and the costs are closely related to the development of wages. Tighter regulations regarding animal welfare and manure handling might also increase costs. Especially in urban and semi-urban areas conflicts on use of area and on manure handling might arise. Recent scenarios for the agricultural sectors do not indicate development that would drastically affect the cost of feed (Sundström et al. 2014) in the Scandinavian countries.

The sensitivity of the horse industry to the economic environment is demonstrated by Hess et al. (2014) who found that the price of riding lessons was positively influenced by the average income level in the nearest town or city. Also, close proximity to larger urban areas contribute to an increase in the price of boarding services (Surry et al., 2013). Both urbanization, increasing level of education and economic growth tend to promote developments in the horse industry. The cost of stabling is relatively high in Sweden (Liljenstolpe 2009) and this may mitigate the expansion of the industry in urban and semi-urban areas. Rural areas have a competitive advantage by having access to sites with more interesting trail characteristics (Blackwell et al. 2009). An analysis using I/O-models reveals that the closed model multipliers were in the range of 2.61-3.19 for the different sector of the Swedish horse industry and between 2.28-3.51 for Norway (Lindberg et al. 2014). The multipliers are in line with multipliers for the food industry in both countries. Hence, the economic impact of changes in the size of the horse industry in Norway and Sweden appears to be rather similar.

Based on results from econometric modelling and future scenarios regarding GDP growth, the horse population is expected to remain rather stable in Norway, while it is much more sensitive to the economic environment in Sweden. Projections reveal that the Norwegian horse industry is quite resilient to economic shocks of the magnitude experienced during the aftermath of the Lehman Brothers crisis in 2008-2012. The Swedish horse industry does not reveal equally resilient features. In Sweden there is also a statistically significant time trend that implies a substantial reduction in the number of horses over time, all else equal. Key issues for the future are the growth in per capita income, a high level of education but also the supply of reasonably priced stabling services and other horse activities particularly in urban and semi-urban areas. Finally, a more far reaching question is how well the horse industries in Norway and Sweden in the future will be able to compete in terms of financial resources as well as for available leisure time among its prospective consumers.

Key words*: Horse sector, future developments, driving forces, Scandinavia.*

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METHICILLIN RESISTANT *STAPHYLOCOCCUS AUREUS* IN PIG SLAUGHTERHOUSES

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Abstract. *Methicillin resistant Staphylococcus aureus (MRSA) has been found in various species of animals, livestock, farmers, slaughterhouses workers and retail meat. During slaughtering process of MRSA positive animals, workers may get infection as well as contamination of carcasses with MRSA may occur.*
The aim of the study was to find out occurrence of MRSA in pig slaughterhouses.
Microbiological samples (n=248) including nasal (n=75), rectal (n=75), samples from pig carcasses (n=80) and environment (n=18) were collected during winter 2013/2014 from three Latvia slaughterhouses with different slaughter capacity. Isolation and identification of the MRSA was done by conventional and molecular methods.
MRSA was found in slaughterhouses average in 53% of pigs. MRSA was detected in 35% of nasal, 21% of rectal and in 6% of samples from pig carcasses. Only 9% of all positive samples, MRSA were found both rectal and nasal samples in animals. In major cases MRSA was detected in pigs 27% only in nasal and 19% - only in rectal samples. There was seen a tendency: as higher the capacity of slaughter, as higher the contamination of pig carcasses with MRSA. According to our data MRSA was found only in carcasses that were prepared with scalding method.
As it is seen from our study, occurrence of MRSA in slaughtered pigs was quite high, but considering good hygiene practice during the meat production process, contamination from slaughtered pigs to carcasses decreased 6 times. The main source of MRSA contamination for carcasses is pigs that are colonized with MRSA.

Key words: *Methicillin resistant Staphylococcus aureus, slaughterhouses.*

SEROPREVALENCE TO BOVINE VIRAL DIARRHOEA AND INFECTIOUS BOVINE RHINOTRACHEITIS VIRUSES IN A NON-VACCINATED DAIRY CATTLE IN LATVIA

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Abstract. *Infection with bovine viral diarrhoea (BVD) virus is recognized throughout the world as one of the main causes of reproductive disorders. Infectious bovine rhinotracheitis (IBR) virus infection most cases run a mild or subclinical course, therefore any animal with antibodies to the virus is considered to be a carrier and potential intermittent excretor of the virus.*

The aim of the study was to determine the prevalence of serum antibodies to IBR and BVD viruses in the dairy cattle herds in Latvia.

A survey of BVD and IBR viruses infections were carried out in a non-vaccinated cattle population from the all regions of Latvia during 2013-2014. Bulk milk samples were selected from 80 herds and blood samples were collected from 578 animals in age from 7 to 11 months. Sera were tested for antibodies using indirect ELISA method in the laboratory of Research institute „BIOR" in accordance to guidelines of OIE Manual Terr.ch. 2.4.13 and 2.4.8.

According to results of bulk milk samples, the prevalence of BVDV and IBRV antibody-positive herds were 19% and 15%, respectively. Exposure to BVD virus was distributed in large and middle size herds, but IBR virus in large ones. Seropositivity to both viruses in 9% of the herds was observed. Sixteen of serotested herds (21%) had at least one positive animal to BVD and six herds (8%) – to IBR viruses. The animal seroprevalence to BVDV was 14%, to IBRV – 4%, but to both viruses – 1.5%. A positive correlation between the number of seropositive cattle and the size of herds was determined.

Conclusions. The fact that vaccination is not practiced in the herds sampled and that had seroprevalence to BVDV and IBRV in animals above 10% indicates that cattles have been previously exposed to above mentioned viruses and that the population is unlikely to contain persistently infected individuals.

Key words: *BVD, rhinotracheitis, IBR, bovine.*

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PARASITOSES IN THE DAIRY CATTLE HERDS IN LATVIA

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Abstract. *The aim of our study was to investigate the prevalence of gastrointestinal parasties in cattles in Latvia. Research was carried out covering all Latvian territory during the period of 2013 until 2014. A total 80 dairy farms were examined, including 2612 coprological samples from dairy cows and cattles from six month to one year old. Research activities were carried out in three different dairy farm groups: small (up to 25 cows in the herd), medium (up to 100 cows in the herd) and large (more than 100 cows in the herd). Coprological samples were investigated at the LUA, Faculty of Veterinary medicine, Institute of Food and Environmental Hygiene, Laboratory of Parasitology. A standardized ovoscopical and larvascopical methods was used to detect helminths. The invasion of extensive margin (IE) was calculated as a percentage. Evaluating the invasion of extensive margins in dairy farms, it was found that in small farms cattle were infected with digestive system strongylida (IE 24.2%), cryptosporidium (IE 21.9%), eimeria (IE 14.3%), moniezia (IE 8.8%), dictyocaulus (IE 3.1%), strongiloides (IE 1.1%) and trichuris (IE 1.1%), but in medium size farms – with eimeria (IE 31.1%) cryptosporidium (IE 23.4%) and digestive system strongylida (IE 22.5%). Less often were diagnosed fasciola (IE 3.1%), strongiloides (IE 2.4%), moniezia (IE 2.4%), trichuris (IE 1,6%), and paramphistomum (IE 0.8%). In large farms eimeria (IE 22.1%), cryptosporidium (IE 18.6%), digestive system strongylida (IE 9.6%), moniezia (IE 9.1%), strongiloides (IE 3.2%) and trichuris (IE 1.7%) were found. Conclusion. Irrespective of a farm type the farm cattle was infected with eimeria, digestive system strongylida and cryptosporidium.*

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Key words*: parasitoses, cows, prevalence, Latvia.*

THE SILAGE COMPOSITION AND ITS INFLUENCE ON DAIRY COWS MILK YIELD

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Abstract. *The purpose of the research was to analyze the composition of maize and grass silages and estimate influence of forage: concentrate ratio on milk yield in dairy cows. Data were collected in 2013 and 2014 and consist of 11 samples of maize silage and 15 samples of grass silage. Dry matter (DM) content was not significantly different between years within silage group. Dry matter content of maize silage was 317.2 ± 15.14 g kg*$^{-1}$ *in 2013 and 361.5 ± 20.61 g kg*$^{-1}$ *in 2014, whereas corresponding DM in grass silage was 303.8 ± 17.58 g kg*$^{-1}$ *and 361.5 ± 20.61 g kg*$^{-1}$*. Crude protein content of DM was significantly higher in grass silage than in maize silage and ranged from 123.9 ± 8.07 g kg*$^{-1}$ *to 137.5 ± 7.12 g kg*$^{-1}$*. Net energy for lactation (NEL) was significantly higher in maize silage than in grass silage and ranged from 6.5± 0.09 MJ kg*$^{-1}$ *to 6.6 ± 0.06 MJ kg*$^{-1}$ *of DM (P<0.05). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) content of DM was lower in maize silage than in grass silage. The range in NDF was from 444.1 ± 12.40 g kg*$^{-1}$ *to 487.1± 17.79 g kg*$^{-1}$*, whereas corresponding ADF ranged from 252.9 ± 7.76 g kg*$^{-1}$ *to 254.4 ± 7.76 g kg*$^{-1}$*. The relationship between NEL and DM content was: NEL=0.0007×DM + 6.3317. Highest forage: concentrate dry matter ratio was 1.24 in May, 2013, whereas highest milk yield was observed in May, 2014.*

Key words: *maize silage, grass silage, forage: concentrate ratio.*

INTRODUCTION

Quality of forage is one of important factors affecting milk quality and quantity in the dairy sector. The production of high quality raw milk is necessary for further processing of raw milk for a high quality food production. A balanced diet for dairy cows provides the nutritional requirements for getting this high quality milk. In many countries, silage constitutes 50 to 70% of dairy cow diets and contribute to a high milk yield [9]. To do that, the diet must contain enough energy and essential nutrients. In that respect, dry matter and composition of dry matter is important. The important nutrients are crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF), starch, crude fat and sugars. Concentration, digestibility and utilization of them determine net energy for lactation (NEL). Quality of forage is affected by factors like botanical composition, climatic conditions, harvesting technology and others [1]. Maize silage is used for elevation of energy of the ration, but nutritional value of this silage is affected by agro-climatic conditions and sowing time [10]. Protein is one important component in high-yielding dairy cows feed rations. In addition to milk yield and quality, the balance between protein and energy affect reproduction traits also [4]. Grass silage is one of important feedstuff that provides protein to for dairy cow feed rations. The process of ensilaging is very important to preserving the protein quality in silage [5]. Legumes like alfalfa provides high content of protein in silage [3]. Fermentation and digestibility in cattle rumen differ between silage types like maize silage, crop silage, grass silage and alfalfa silage. For example, NDF digestibility was higher for grass silage compared with wheat silages [23]. For both silages, adding concentrates to total mixed ration (TMR) is the best solution for balancing energy and protein requirements. However, the quality of silages affected the proportion of concentrates in TMR. Increasing concentrates in TMR increase not only milk yield, but change milk composition also [26]. Moreover, high producing dairy herds attempting to maximize energy intake are continually confronted with subclinical acidosis and laminitis. These diseases are results of unbalanced dairy cows feeding [21].
The purpose of research was to analyze the composition of maize and grass silages and estimate influence of forage: concentration ratio on dairy cows milk yield.

MATERIALS AND METHODS

The location of research was Latvia University of Agriculture Training and Research farm. Data were collected from 2013 and 2014 and consists of 11 samples of maize silage and 15 samples of grass silages. Samples of silage were collected by using silage probe in the full depth of the pit along two intersecting diagonals. The samples of silage were inserted in polyethylene bags, which protected them from environment impact. Average weight of the silage samples were 0.5 to 1.0 kg. The samples were analyzed in LUA Scientific Laboratory of Agronomic analyses according to international methodology (Table 1).

Table 1

Analyzing sample count and methods

Traits	Sample count (n)	Method
Dry matter	26	Forage analyses, USA, met. 2.2.1.1:1993, *met. 2.2.3.:1993
Crude protein	26	LVS EN ISO 5983-2:2009
NDF	26	LVS EN ISO 16472:2006
ADF	26	LVS EN ISO13906:2008
Ash	15	ISO 5984:2002/Cor 1:2005
Ca	16	LVS EN ISO 6869:2002
P	16	ISO 6491:1998
pH	15	ГОСТ 26180-84, met.3
Starch	11	LVS EN ISO 10520:2001
NEL	26	Calculated by formula: (0.00245×digistibility of DM-0.12)×4.184

Data of dairy cows feed ration and milk productivity were collected from monthly milk recording results until 110th lactation day (high-yielding group). The cows were kept in a loose housing system and fed with TMR. The TMR contained 34-50 kg forage (respectively 60% grass silage, 40% maize silage, 1.0 kg hay). The remaining part was concentrates (6.8- 7.0 kg barley flour, 2.5-2.8 kg rapeseed cake, 2.0-2.5 kg soybean cake, 0.3-0.4 propylene glycol, 1.0 kg molasses, 0.5 kg energy feed, 0.2 kg mineral (SelenPlex, Biotin Plus et al.), 0.15 kg chalk, 0.25 kg banking soda, 0.04-0.06 kg salt). Digestibility of dry matter in maize silage was 68% in 2013 and 69% in 2014. Corresponding digestibility of grass silage was 60% in 2013 and 59% in 2014. The cows were fed 2 times per day and milked 3 times per day in parallel milking parlour. The cows were from different breeds (Holstein Black and White, Holstein Red and White, Danish red, Latvian brown with different blood) and lactations and averaged 2.5 lactations in 2013 and 2.1 lactation in 2014.
Forage: concentrate ratio was (F:C ratio) was calculated according to formula:

$$F : C \quad ratio = \frac{F}{C} \ , \tag{1}$$

where: F – forage dry matter weight, kg
C – concentrate dry matter weight, kg.

The data processing was carried out with SPSS and MS Excel programs. T tests for independent samples was used for determination of significant differences between treatments ($P<0.05$).

RESULTS AND DISCUSSION

The composition of grass and maize silage is presented in the table 2. Dry matter of maize silage was 317.2 ± 15.14 g kg^{-1} and 361.5 ± 20.61 g kg^{-1} in 2013 and 2014, respectively, but not significantly different between years. According to other studies, DM of maize silage can range between 230 to 380 g kg^{-1} dependent on harvesting time and other factors [24], [6]. Dry matter of grass silage was 303.8 ± 17.58 g kg^{-1} the first year, and increased to 321.00 ± 21.58 g $kg^{-1}$the second year Similar to maize silage, DM was not significantly different between years. Dry matter content in silage affect DM intake. For example, if DM is lower than 250.0 g kg^{-1}, dairy cows eat enough silage and concentrate content in TMR must be increased [11]. Crude protein of DM was higher in grass silage than in maize silage. Highest crude protein content was 137.5 ± 7.12 g kg^{-1} DM in 2013. According to other studies, average crude protein content of DM was

124 g kg^{-1} in grass silage, compared to 144 g kg^{-1} in grass and red clover mixture silage [14]. Crude protein of DM ranged of 77.4 ± 4.49 g kg^{-1} to 80.5 ± 1.60 g kg^{-1} in maize silage, which is lower than 85.0 g kg^{-1} reported by USA scientists' [7].

NDF content of DM was higher in grass silage than in maize silage both years. Highest NDF content of DM was 566.3 ± 23.10 g kg^{-1} in grass silage in 2014, whereas highest NDF of maize silage DM was in 487.1 ± 17.79 g kg^{-1} in 2013. NDF content of maize silage DM was similar to other research results [27]. However, NDF values of our study were high compared with Dutch studies. The additives and harvesting time affected ensiling process of silage [8].

ADF content of DM was higher in grass silage than in maize silage. Highest ADF content of maize silage was found in 2014 and was 254.4 ± 7.76 g kg^{-1}. ADF of grass silage DM was also highest in 2014.

NEL of maize silage DM was higher than in grass silage DM both years, with highest values found in 2014. Energy value of maize silage DM is depends on the cultivar and the harvesting time [12]. Evaluating the traits mentioned above, we concluded that the quality of both silages is good for dairy cows diets.

Table 2

Silage composition

Component	Grass silage		Maize silage	
	2013	2014	2013	2014
Dry matter, g kg^{-1}	303.8 ± 17.58	321.0 ± 21.58	317.2 ± 15.14	361.5 ± 20.61
Crude protein, g kg^{-1} DM	137.5 ± 7.12	123.9 ± 8.07	77.4 ± 4.49	80.5 ± 1.60
NDF, g kg^{-1} DM	535.3 ± 15.93	566.3 ± 23.10	487.1 ± 17.79	444.1 ± 12.40
ADF, g kg^{-1} DM	373.8 ± 13.08	387.7 ± 16.25	252.9 ± 7.76	254.4 ± 7.76
NEL, MJ kg^{-1} DM	5.7 ± 0.13	5.5 ± 0.13	6.5 ± 0.05	6.6 ± 0.06
Ca, g kg^{-1} DM	11.9 ± 2.0	8.8 ± 1.30	-	1.52 ± 0.50
P, g kg^{-1} DM	2.9 ± 0.10	2.4 ± 0.2	-	1.83 ± 0.6
Starch, g kg^{-1} DM	-	-	271.8 ± 15.3	308.9 ± 15.7
Ash, g kg^{-1} DM	86.5 ± 7.20	-	40.1 ± 3.45	85.7 ± 6.59
pH	4.49 ± 0.22	-	3.88 ± 0.70	-

A balance between NDF, ADF and NEL in TMR are important for high milk yield and health of dairy cows. NDF content of TMR should not be lower than 280.0 g kg^{-1}, of which 75% must be provided from forage. However, it is important to take into account that NDF affect DM intake. Therefore the content of NDF cannot be too high. Starch content is an important component in maize silage and needs to be assess in TMR, especially in early stage of lactation when the papillae is not adapted for intensive fermentation [29]. ADF is an important factor for feed digestibility [12].

Calcium content of DM was highest in grass silage in 2013 and reached 11.9 ± 2.00 g kg^{-1}. Ash, starch and pH were analyzed for the half of the total samples. Ash content of DM significantly differed between maize and grass silages ($p<0.05$). Highest ash content was found in grass silage in 2013 and averaged 86.5 ± 7.20 g kg^{-1}. Increased ash content can be connected with silage harvesting process and soil part pick up from field [15]. Other scientists have found similar results of ash content in grass and maize silage. According to them, ash content of DM should not be higher than 100 g kg^{-1} [19],[16].

In the analyzed period, pH value of the grass silage was 4.49 ± 0.22, whereas pH value of the maize silage was 3.88 ± 0.70.

The relationships between NEL and DM in silages are illustrated in Figure 1. Analyzing the relationship between DM and NEL, we found that increased DM of maize silage by 1 g increased NEL by 0.0007 MJ kg^{-1} of DM, whereas in grass silage the increase in NEL was 0.0032 MJ kg^{-1} of DM. This effect can be explained by fact that starch accumulate as plants are aging. According to investigation carried out in Lithuania, NEL value increased by 0.043 MJ kg^{-1} of DM if DM increased by 10 g kg^{-1} [25].

There was a weak positive correlation between DM content and NEL in maize silage (r_p= 0.23). In grass silage the correlation was r_p= 0.46. The best influence on rumen environment and silage digestibility have been reported to be when DM content of silage was 300-400 g kg^{-1} at harvesting time [2].

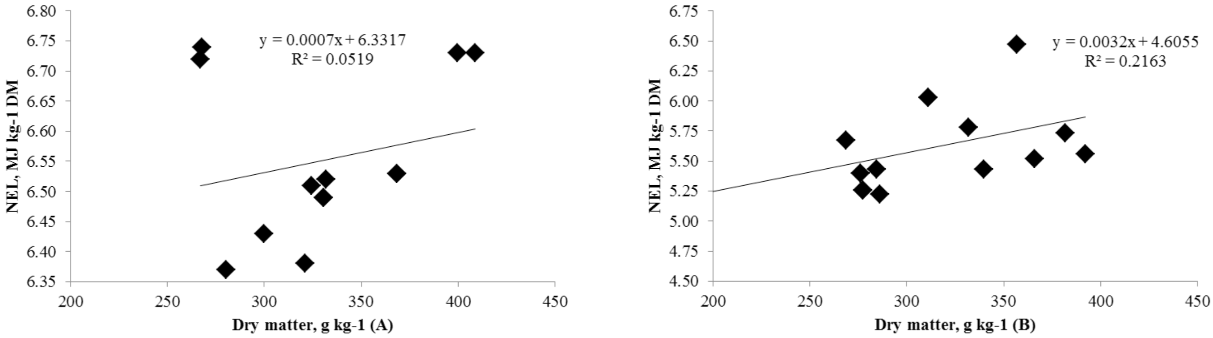

Figure 1. **Relationship between NEL and DM (A – maize silage, B – grass silage)**

Forage: concentrate ratio characterize the dry matter of forage and concentrate relationship in TMR. Our research results of F:C ratio and milk yield are illustrated in Figure 2. If F:C ratio value is higher, it means that forage content increased in TMR. Lowest F:C ratio was found in November 2014 when it decreased to 0.78.

Highest daily milk yield was found in May 2014 when it averaged 42.3 kg. At the same time, F:C ratio was 0.89. We found that the trend was that milk yield increased when forage content decreased and concentrate content increased in TMR. In early lactation stage, the intake of more concentrates is important to avoid negative energy balance [13]. Dutch scientists that, analyzed influence of TMR on dairy cows milk productivity with F:C dry matter ratio of 0.45, or only 35% forage dry matter in TMR, found a milk yield that increased to 48.0 kg [28].

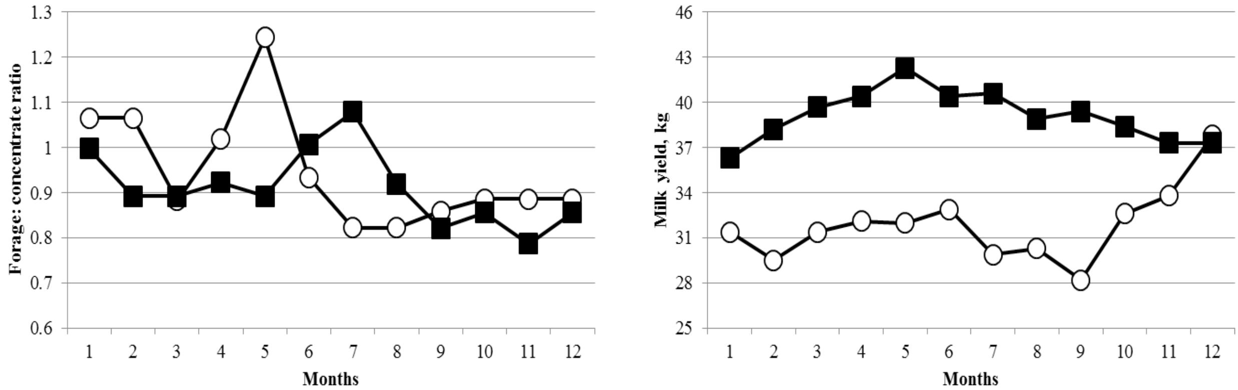

Figure 2. **Forage: concentrate dry matter ratio and milk yield: ○ 2013; ■ 2014 year**

Milk yield can be affected by different factors, for example, grass and maize silage ratio and ingredients of concentrate. Merten recommends that optimal value of F:C dry matter ratio should be between 0.7 and 1.5. The risk of developing different diseases, for example, acidosis, lameness increase when F:C ratio is lower and it can end with culling of dairy cows [17],[18]. Our results are in line with Merten's recommendations. It is important not only to get a high milk yield, but also to produce it profitable. Controlling forage harvesting and dairy cows feeding process is important for dairy cows longevity and environment protection. This and the health of dairy cows can be achieved by use of balanced diets [20].

CONCLUSIONS

Dry matter content was not significantly different between years in each silage group. Highest DM content was in maize silage in 2014 and averaged 361.5 ± 20.61 g kg^{-1}.

Chemical composition was not significantly different between years in each silage group. Crude protein of grass silage DM was highest in 2013 (137.5 ± 7.12 g kg^{-1}), whereas highest NEL of maize silage was found in 2014 (6.58 ± 0.06 MJ NEL kg^{-1}). There was a positive correlation between DM and NEL of r_p= 0.23 in maize silage and r_p= 0.46 in grass silage. Highest milk yield was observed in 2014, when forage to concentrate dry matter ratio was lower.

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THE PRODUCTION AND QUALITY ANALYSIS OF LATVIAN DARKHEAD BREED LAMBS

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Abstract. *In Latvia, people predominantly breed Latvian dark head breed lambs with seasonal rutting between July and December. Due to economic reasons, part of the sheep breeders organize the lambing of ewes in spring months, when lambs are born in April, May, shortly before the beginning of the pasture season. The lambing season of ewes affect the development and growth of lambs, predominantly the increase in live weight per day. The aim of the study – to analyse the impact of lambing season of ewes on lamb growth rates during the lactation period. The farm being studied is situated in Latvia, in Northern Vidzeme and mostly breeding Latvian dark heads breed. This study uses the production results for farm-born lambs in 2013 and 2014. For the purposes of data analysis we established 3 groups, depending on the lambing season and lamb gender. By performing the variance analysis of the results obtained, we concluded that the age of ewes had a significant impact on the number and live weight of lambs at birth, and the fertility of ewes had a significant impact on breeding of lambs. The ewes of spring-born lambs were 3 years old on average and 2 lambs per ewe lambed were obtained on average, which differed significantly from winter and summer-born lamb groups. During the study, it was demonstrated that the number of lambs per litter affects the live weight of lambs at birth, the spring-born male (3.8 kg) and female (3.7 kg) lambs were significantly lighter than those born in winter and summer. During the lactation period, the highest increase in daily live weight was obtained from summer-born lambs of both genders. The male lambs reached 287.3 g and the female lambs – 269.0 g. According to the results obtained in the study, we conclude that the largest number of ewes lambed in spring, and they are most efficiently used during this season.*

Key words: *Latvian dark head lambs, lambing season, live weight, litter size at birth, growth gain.*

INTRODUCTION

In Latvia, people predominantly breed Latvian dark head breed lambs with seasonal rutting between July and December. Due to economic reasons, part of the sheep breeders organize the lambing of ewes in spring months, when lambs are born in April, May, shortly before the beginning of the pasture season.

Depending on the sheep mating time, lambing of sheep takes place mainly in two periods, and therefore it is common to divide between lambing in winter and spring months. Lambing of sheep in winter takes place in December, January and February, which is the coldest time of year. In Latvia, lambing of ewes traditionally occurs in winter months. Lambing of sheep in spring takes place in the warmest months: March, April and May. Such organization for lambing of ewes is suitable for sheep farms, where sheep are kept in cold sheds, lightweight construction buildings, or outdoors throughout the year. The advantage of lambing of ewes in spring is the fact that sheep with lambs consume a smaller amount of winter feed, especially fodder, since sheep and lambs are kept in a shed for a smaller period of time. As early as in May, sheep and lambs may be placed on the pasture, where they can consume fresh, protein-rich pasture grass.

The advantage of lambing of ewes in winter is the fact that sheep reach their breeding readiness in the autumn period (during the season of intensive rutting), which is particularly important for selling of breeding animals, since the owners are willing to buy breeding animals as soon as in August. A prerequisite for organising the lambing of ewes in winter is a thermally insulated shed. Some of the shortcomings are larger consumption of fodder and high costs for construction of a shed, since a thermally insulated shed must be built [6].

One of the main characteristics of sheep productivity is production and rearing of lambs. The main factors affecting it are the number of lambs at birth, milkiness of ewes, behaviour of ewes (maternal instinct), lamb health condition and organization of feeding.

The lambing season of ewes affect the development and growth of lambs, predominantly the increase in daily live weight. It is preferable to mate ewes in late summer (so that they would lamb in winter), and maintain a greater number of old sheep (from 4 to 6 years) in the flock. When feeding the ewes, most attention should be paid to the second half of gestation (100th day), obtaining lambs with higher live weight at birth (3.5-5.0 kg), which will further affect their growth rate [10].

The number at birth has a significant impact on the number of lambs weaned. It is easier to preserve the lambs born as singles or twins, rather than those born as triplets or quadruplets. Preservation of lambs also depends on the technology used for provision of sheep and rearing of lambs applied in the farm.

The aim of the study – to analyse the impact of lambing season of ewes on lamb growth rates during the lactation period.

MATERIALS AND METHODS

The farm being studied is situated in Latvia, in Northern Vidzeme. The farm is breeding Latvian dark heads, Oxford Down and Texel sheep breeds. On 01/01/2015, the total number of sheep of different age was 851. The farm pays great attention to preparation of good roughage. In spring, following the weaning of lambs, ewes and lambs are grazed in good-quality cultivated pastures providing all the necessary nutrients. Based on the fact that the Latvian dark head is the basic breed in Latvia, this study analyses the growth of Latvian dark head breed lambs during the lactation period and quality during the evaluation. This study uses the production results for farm-born lambs in 2013 and 2014. For the purposes of data analysis we established 3 groups, depending on the lambing season and lamb gender, where the highest number of lambs – 83.1% were born in spring, 11.1 % of lambs were born in summer and 5.8% were born in winter (Table 1).

Table 1

Number of lambs of the study seasons

Lambing seasons	Male	Female	Together	%
Winter	10	9	**19**	**5.8**
Spring	147	123	**270**	**83.1**
Summer	15	21	**36**	**11.1**
Together	**172**	**153**	**325**	**100**

The winter season included lambs born in December, January and February, the spring season – lambs born in March and April, and the summer season – lambs born in May, June and July. Data on the number of lambs at birth, live weight at birth, the increase in live weight per day until weaning and adjusted live weight at 70 days of age were obtained from the Agricultural Data Centre database. According to a breeding programme developed in Latvia for Latvian dark head breed sheep, lambs are evaluated between the 60th and the 95th day of life, the live weight of lambs during the evaluation is determined and recalculated to 70 days of age, so that the lambs might be divided into the relevant classes (from Elite – Class II) [2].

During the study, in order to characterise the efficiency of ewes, the live weight of lambs with 70 days of age obtained from a single ewe has been calculated.

The data obtained were processed using the software *MS Excel*, using mathematical data processing methods. The average values, standard error and coefficient of variation of the characteristics listed were calculated. The significance of differences among the average values was determined using the t – test, and the impact of factors – single-factor analysis of variance. In order to describe the significance of differences in the results obtained, we used the following Latin alphabet letters: a; b; and c ($p \leq 0.05$).

RESULTS AND DISCUSSION

Live weight and growth rate during the lactation period is affected by gender and number of lambs at birth, live weight and feeding of the ewe, breed, as well as external environmental factors [9].

By performing the variance analysis of the results obtained, we concluded that the age of ewes had a significant impact on the number and live weight of lambs at birth, and the fertility of ewes had a significant impact on breeding of lambs. Table 2 summarizes the average number and live weight of lambs at birth born in different seasons, as well as information on the average age of ewes.

Table 2

Averages of lamb birth parameter and age of sheep by lambing seasons

The outcomes	Lambing seasons					
	winter		spring		summer	
	male	female	male	female	male	female
	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$
Age of sheep, years	2.8±0.20[a]	3.3±0.29[a]	3.1±0.07[b]	2.9±0.07[b]	1.5±0.13[c]	1.5±0.05[c]
Size at birth	1.7±0.15[a]	1.9±0.11[a]	2.0±0.04[b]	2.0±0.04[a]	1.2±0.11[c]	1.3±0.10[b]
Live weight at birth, kg	4.7±0.34[a]	4.5±0.25[a]	3.8±0.07[b]	3.7±0.07[b]	4.3±0.24[a]	3.8±0.17[b]

[a;b;c] $p \leq 0.05$ – productivity characteristics of lambs of the same gender according to different seasons of birth

As evidenced by the results obtained, the youngest ewes have lambed in the summer season (1.5 years) and are significantly younger than the ewes that have lambed in the summer and winter seasons. The oldest ewes that have given birth to female lambs were 3.3 years old, which is by 0.4 years older than the ewes that lambed in spring ($p \leq 0.05$). The significantly older ewes (3.1 years) that have given birth to male lambs lambed in spring. By mating the breeding sheep from 10 to 12 months of age, the vast majority of young sheep gives birth to only 1 lamb, this can be attributed to a significantly smaller number of lambs per litter during the summer season of lambing, both in male and female lamb groups. In both male and female lamb groups, significant differences were observed in age of ewes between winter and summer, as well as between spring and summer seasons of lambing ($p \leq 0.05$). The results obtained from studies with Merino sheep carried out in South Africa confirmed that age, live weight and year of birth of ewes had a significant impact ($p \leq 0.01$) on lamb productivity characteristics. A significant impact on live weight of lambs weaned (60 days) in the first lambing of sheep was obtained. From sheep born as twins a 7.6% (0.40 lambs) increase in lambs obtained and a 7.4% (0.30 lambs) increase in lambs weaned was observed if compared to their peers born as singles [3]. Similar results were obtained in studies conducted in New Zealand [7].

By analysing the average number at birth in male and female lamb groups, the largest number was obtained in the group of ewes lambing in spring – 2.0 lambs per ewe, but the lowest result – from ewes lambing in summer 1.2 and 1.3 lambs per litter respectively. The number of summer-born lambs at birth was significantly lower than winter and spring-born lambs ($p \leq 0.05$). Significant differences in number at birth were also observed among male lambs born in winter and spring ($p \leq 0.05$). The results obtained from studies carried out in Turkey with local and Romanov breed sheep regarding seasonal effects on lamb growth and development confirmed that the number of lambs at birth in winter season of lambing was higher, 1.27 lambs per litter on average, but lower in spring – 1.26 lambs per litter. A higher live weight at birth was demonstrated by Romanov breed lambs: 4.3 kg in winter season and 3.9 kg in summer season [5].

The studies conducted in Australia found that male lambs were significantly heavier by 0.2 kg ($p \leq 0.05$) on average compared to the female lambs and that lambs born as singles were heavier by 1.1 kg ($p \leq 0.001$) on average than twin lambs [4], [8].

A similar trend was also observed in our study, where the smallest live weight at birth was found among the spring-born male lambs – 3.8 kg and female lambs – 3.7 kg. If compared to the spring-born lambs, significantly heavier lambs were born in winter, 4.7 kg and 4.5 kg respectively, demonstrating a 0.9 kg increase for male and a 0.8 kg increase for female lambs. In male lamb group, significant differences in live weight at birth between winter and spring seasons of lambing ($p \leq 0.05$) were observed. In female lamb group, significant differences in live weight at birth between winter and spring seasons of lambing ($p \leq 0.05$) were observed. Although the number of lambs per litter born in summer constituted 1.3, their live weight was not significantly different if compared to summer-born female lambs. The study carried out in Lithuania using Lithuanian blackhead breed sheep also showed that winter-born lambs were by 0.2 kg heavier – 3.94 kg than those born in spring – 3.74 kg [10].

An important characteristic of meat productivity is increase in daily live weight characterizing the lamb growth ability. By performing a monthly control weighing of lambs, we can calculate the increase in daily live weight of lambs. See Figure 1 for increase in daily live weight of male and female lambs until evaluation.

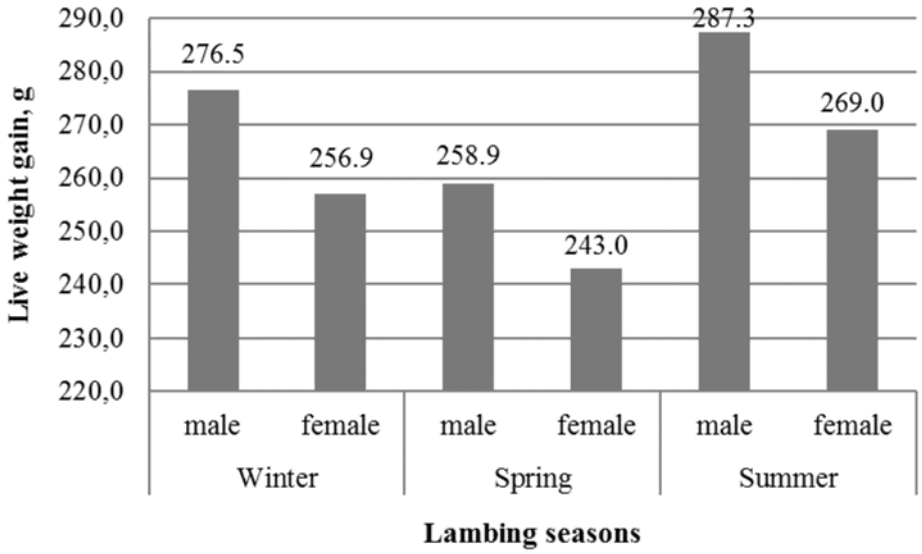

Figure 1. **Male and female average daily live weight gain depending on the season**

As demonstrated by the results obtained, in different seasons of birth, male lambs showed a greater increase in daily live weight until evaluation if compared to female lambs. Increase in daily live weight of summer-born male lambs during the lactation period constituted 287.3 g, which is by 10.8 g higher than for lambs born in the winter season and by 28.4 g higher than for lambs born in the spring season respectively. Increase in daily live weight of summer-born female lambs during the lactation period constituted 269.0 g, which is by 12.1 g higher than for lambs born in the winter season and by 26.0 g higher than for lambs born in the spring season respectively. This can be explained by balanced feeding of ewes and lambs using good-quality grass feed during the summer months. No significant differences in increase in daily live weight of lambs until weaning among different seasons of lambing were observed.

In order to evaluate the quality of farm-grown lambs, the adjusted live weight of male and female lambs at 70 days of age (Figure 2) has been calculated. Based on the requirements of the breeding programme for Latvian dark head breed lambs, lambs born as singles should weigh at least 20 kg, and the lambs born as twins – at least 18 kg.

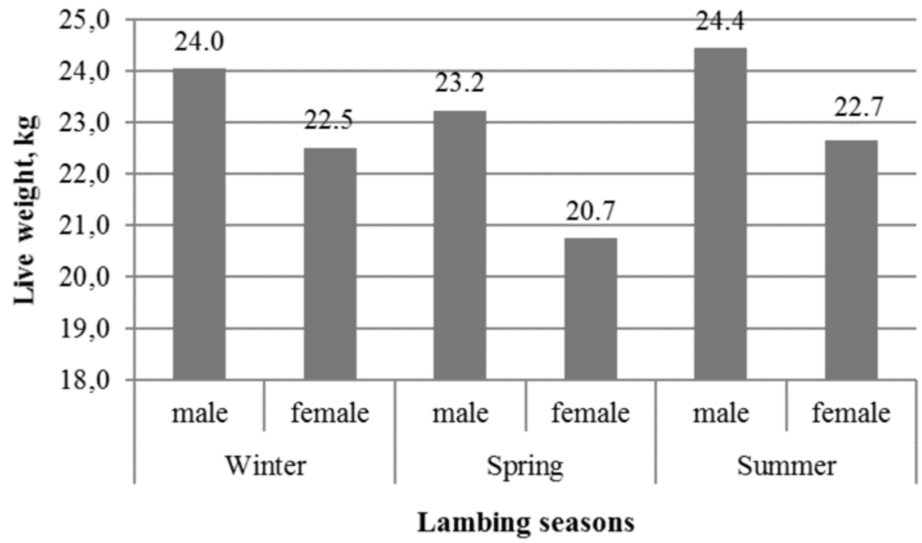

Figure 2. **Male and female average live weight until weaning depending on the season**

The results summarized in the figure show that in all seasons of the study lambs of both genders at 70 days of age have exceeded the requirements specified in the breeding program. Organizing the lambing of ewes in

the farm during the summer months has resulted in the highest adjusted live weight of lambs of both genders at 70 days of age – 24.4 kg for male and 22.7 kg for female lambs, which was by 0.4 kg higher than for winter-born and by 1.2 kg higher than for spring-born male lambs. In the female lamb group, this indicator was by 0.2 kg higher than for winter-born and by 2.0 kg higher than for spring-born lambs. No significant difference in adjusted live weight of lambs at 70 days of age was observed. The study results obtained in Turkey are different from our findings. In studies carried out there on seasonal effects on the growth and development of lambs, the spring-born lambs after weaning (at 60 days of age) were by 1.6 kg heavier (18.3 kg) ($p < 0.05$) than the winter-born lambs – 16.7 kg [5]. The results obtained in Lithuania are similar to our results of the study, where winter-born lambs at 60 days of age reached 26.15 kg, and were by 8.4 kg heavier than the spring-born lambs [10]. The results of studies conducted confirm that female lambs are born with a lower live weight, obtain a lower increase in live weight per day, weighing less than the male lambs at 70 days of age. In studies conducted in Turkey using Akkaraman sheep breed, the weaning live weight of female lambs at 60 days of age reached 15.9 kg, and for male lambs – 17.1 kg [1].
Table 3 summarizes the results calculated for evaluation of ewe efficiency according to lambing seasons.

Table 3

The lamb average live weight to the lambing sheep in different seasons

Parameters	Winter		Spring		Summer	
	male	female	male	female	male	female
Lamb extraction (mother fertility)	1.7	1.9	2.0	2.0	1.2	1.3
Lamb live weight of the 70 days, kg	24.0	22.5	23.2	20.7	24.4	22.7
Lamb live weight to the lambing sheep, kg	40.8	42.8	46.4	41.4	29.3	29.5

Results of calculations made show that ewes have been most efficiently used in the spring season, when 46.4 kg of live weight per ewe were obtained on average in the male lamb group, which is by 5.6 kg higher than for winter-born and by 17.1 kg higher than for summer-born lambs. The most efficient use of ewes in production of female lambs has been observed in the winter season, where the average live weight of lambs at 70 days of age per ewe constituted 42.8 kg, which is by 1.4 kg higher than for spring-born and by 12.3 kg higher than for summer-born lambs.

CONCLUSIONS

1. The ewes of spring-born lambs were 3 years old on average and 2 lambs per ewe lambed were obtained on average, which differed significantly from winter and summer-born lamb groups ($p \leq 0.05$).
2. During the study, it was demonstrated that the number of lambs per litter affects the live weight of lambs at birth, the spring-born male (3.8 kg) and female (3.7 kg) lambs were significantly lighter than those born in winter and summer ($p \leq 0.05$).
3. During the lactation period, the highest increase in live weight per day was obtained from summer-born lambs of both genders. The male lambs reached 287.3 g and the female lambs – 269.0 g. The adjusted live weight of these lambs at 70 days of age was the highest among the study groups reaching 24.4 kg for male lambs and 22.7 kg for female lambs.
4. According to the results obtained in the study, we conclude that the mating and lambing of ewes in the farm is organized in accordance with the strategy developed, – the largest number of ewes lambed in spring, and they are most efficiently used during this season.

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SMART FARMING TECHNOLOGIES AND SUSTAINABLE ENERGY

MODERN AND SMART FARMING TECHNOLOGIES

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Abstract. *Increasing world populations and increasing expectations are causing a need for more and more agricultural production of food, feed, fibers, and fuels. While resources are being consumed, and with problems such as urbanization, desertification, salinization, climate change, and soil degradation, it is imperative that increasing quantities and improved qualities of agricultural plant products be produced with environmental, economic, and social sustainability.*

Smart farming is needed to assist with this task. Technology alone will not solve these problems, but technologies can help to gather data, remember and process data and information, and achieve more optimal control of machines and processes. This talk discusses some of the contemporary technologies for smart agronomic and horticultural farming.

Basic concepts, historical developments, and contemporary situations, including research and commercial adoption, are discussed. Due to time constraints, only selected examples can be covered. There is an emphasis on precision agriculture technologies. Some technologies for robotics and sensing are also discussed.

FUTURE DEVELOPMENT PERSPECTIVES OF THE PRECISION APICULTURE (PRECISION BEEKEEPING)

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Abstract. *Precision Beekeeping (or Precision Apiculture, PB) is considered as a sub-branch of Precision Agriculture. Precision Beekeeping is defined as an apiary management strategy based on the monitoring of individual bee colonies to minimise resource consumption and maximise the productivity of bees. There are different tasks for PB at the bee colony and apiary scales both in passive and active periods of honey bee colony development. It is important to remotely detect different states of the bee colonies, like developmental states, several events, that may require beekeeper's actions, including swarming, extreme nectar flow, queenless states etc.*

Although there are sufficient technical means (different sensors, specific measurement systems, monitoring systems) and industrial products for the practical execution of PB, the implementation process is slow due to the differing states of development of three implementation phases: data collection, which is the most developed and advances phase to this moment, data analysis and application. Currently available PB systems are not widely used because of several reasons: technical systems are complicated for beekeepers; benefits of usage of systems are not clear and there are additional operational costs of systems.

The development and practical implementation of decision support systems (DSS), which is usually a stumbling block in Precision Agriculture, is suggested to be an important task. In the long term perspective, specific DSS-controlled electronic devices should be developed to enable new functionalities for PB. Specific classes of actors are proposed to operate within future PB systems for the automatic execution of suggestions made by decision support systems, as well as for diagnostic purposes. PB systems should be optimised by searching for appropriate combinations of different sensors, and corresponding decision support systems must provide convenient, reliable and cost efficient solutions. The development and specification of PB systems should consider business interests, distance to the apiary, expected risks and other peculiarities.

The future implementation of the PB approach is determined by several factors: convenience of PB technology implementation by a beekeepers and clear economic benefits by which, the calculations of return on investment can be reliable. The second point requires scientific efforts to increase the reliability of data analysis and suggestions made by DSS.

Key words: *Precision Beekeeping, Precision Apiculture, bee colony monitoring, decision support systems.*

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AGRICULTURAL BIOGAS PLANTS – ENERGY BALANCE

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Abstract. *Greenhouse gas (GHG) emissions from agriculture could be reduced by producing biogas from animal manure. Biogas production would reduce methane emissions from stored manure and provide climate-neutral methane gas, which could be used for energy purposes, improving the GHG balance. One problem for farmers could be the investment costs for biogas plants, which are currently high. This study compared energy production in two dairy manure-based, farm-scale biogas plants in Norway and the energy consumption in producing this energy. The results for the plants, which had no heat exchanger and minimal insulation on the biogas reactor, clearly demonstrated the necessity of using a co-substrate with dairy manure. Using only manure during January at the Åna plant, SW Norway, resulted in only 10% net energy production. The best result obtained when using co-substrate was 73% (fish ensilage; October). Maximum biogas yield of 0.355 m^3 CH_4/kg VS was recorded by having 31% of total VS provided by fish ensilage with 31 days retention time. Using food waste to supply 29% of total VS gave maximum biogas yield of 0.268 m^3 CH_4/kg VS with 23 days retention time. There were also differences between the plants, which were of different designs. The lowest heat consumption was observed for the Åna plant with its one reactor (in October) and the highest heat consumption for the Tomb plant with its two reactors running in parallel (in January/February). Reactor design probably resulted in higher heat consumption for all periods in the Tomb plant, as biogas storage capacity can be too small when only the headspace of the reactor(s) is used for storage. External biogas storage capacity is recommended.*

Key words: *Agriculture, manure, biogas, energy balance.*

INTRODUCTION

Emissions of CH_4 and N_2O are regulated as part of the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC). The greenhouse gas (GHG) reduction target for the European Union (EU) is 9% by 2008-2012 compared with 1990, and the EU has approved a further reduction target of 40% by 2030 [1]. Biogas production has been introduced by the Norwegian government as a contribution to reducing GHG emissions from the agriculture sector, in a white paper which specifies that 30% of the livestock manure on Norwegian farms should be used for biogas production by 2020 [2]. Furthermore, the EU 2030 target has been adopted in Norway [3]. Production of biogas through anaerobic digestion (AD) of manure is regarded as a viable method to reduce emissions from agricultural activities [4].

Anaerobic digestion of manure provides the potential for production of renewable energy, but the process also requires thermal energy to heat new substrates and to cover heat losses from reactor/s and pipes. The amount of energy required depends on the temperature in the digester, the ambient temperature, the temperature of new substrates and the amount of insulation used on the reactor/s and pipes [5]. Energy recovery devices such as heat exchangers can reduce the demand for thermal energy [6]. Using a heat exchanger to enable the digestate to heat new substrates improves the energy efficiency of the process. However, the high investment costs limit the use of this type of equipment on smaller farm-scale biogas plants. Agriculture in Norway is characterised by relatively small farms [7], and biogas plants thus have to be relatively small to fit the farm structure. Moreover, small biogas reactors have a large surface area per unit volume compared with larger reactors, which can reduce the energy efficiency. In addition, mean annual temperature in Norway is below 10ºC [8], and during the winter the temperature in many areas is below 0ºC for several months. This requires insulation to keep the heat losses at an acceptable level.

It has been shown that the total reduction in GHG emissions from manure management depends not only on reducing GHG losses from manure during storage and field application, but also on the substitution effect of biogas compared with fossil fuel. Therefore, reduced internal use of energy is positive, as it leads to increased substitution of fossil fuel. It has been concluded that substitution of fossil fuel has the greatest potential to reduce GHG emissions [9].

Farm-scale biogas production is anticipated to be one of the future suppliers of renewable energy in Norway. Despite the large areas of non-productive mountain in the country, the total potential of agricultural biogas from straw and manure is estimated to be 3055 GWh year $^{-1}$ [10]. By including energy crops and food waste as co-substrates, this figure could be increased. However, due to high investment costs for biogas production, there are currently fewer than five operative farm-scale biogas plants in Norway [11)].

The small farm size and the scattered pattern of farming areas caused by mountains and fjords do not favour large-scale biogas systems in Norway. The relatively large heat losses from small reactors, combined with the harsh climate and limited experience of building biogas plants for cold climate areas, indicate a need for improving the energy efficiency of biogas plants. The present analysis, which is based on data from two Norwegian biogas plants, sought to identify crucial characteristics in plant design and in choice of substrates.

MATERIALS AND METHODS

The two farm-scale biogas plants Åna in Rogaland on the SW coast [12] and Tomb in Østfold in SE Norway [13] were investigated in terms of their energy balance, the energy contribution from the different substrates they use and the possibility of optimising energy production. Both plants use dairy cow slurry as the main substrate, while the co-substrate at the Åna plant is fish ensilage and at the Tomb plant it is food waste.

The Åna biogas plant consists of one circular 314 m^3 reactor made from 4 m high concrete elements, insulated on the inside by 100 mm thick insulating foam plates. The biogas is transported from the reactor via a fan to a gas boiler. The biogas is used to heat water for the heating system in a prison located near the farm. The hot water boiler can use oil as an alternative fuel and is only switched to biogas when the gas pressure in the headspace of the reactor is high enough to feed the boiler to 100%. The temperature in the reactor is set to 37ºC and the reactor is run semi-continuously and fed 5 times per day. An electrical propeller stirs the reactor contents continually. The following parameters were recorded during the test period (July 2009-June 2011): Gas production, energy consumption (electrical and thermal), daily volume of substrates used, and chemical composition of substrates and digestate (occasionally). The gas storage unit consists of the headspace of the reactor.

The Tomb biogas plant is of a different design. It consists of two reactors, each 175 m^3, running in parallel. The reactors are made of insulated plastic material and most of the body is below the soil surface. Inside the reactors there is a fibreglass reinforced plastic sheet. A positive displacement pump (lobe type pump) is used as a metering device when pumping substrate (food waste and manure) in and digestate out. Each reactor has a propeller-type stirrer. The temperature in the reactors is set to 37ºC, but due to problems with the heating system in the reactors, the actual reactor temperature was several degrees lower for most of the study period. The biogas is combusted in a boiler located close to the reactors and the hot water is pumped to nearby (500 m) school buildings and dormitories, where it is used for heating. The heat losses in this pipe were included in the heat losses from the plant. The following parameters were recorded during the monitoring period (April 2012-June 2013): Energy production, energy transfer to school buildings, daily volume of substrates used, and chemical composition of substrates and digestate (occasionally).

RESULTS AND DISCUSSION

From the long series of monitoring data for the two plants, data for short periods with a stable supply of substrate were selected. Three such periods were selected for the Åna plant, while 21 short periods were used for further analyses of the Tomb plant and from these 21 periods, four longer periods were created according to ambient temperature; April/May 2012, November/December 2013, January/February 2013, and March/April 2013.

The average values in each of the periods were calculated separately for the Åna plant (Table 1) and the Tomb plant (Table 2). The retention time varied in the study period, mainly due to varying volumes of substrate

treated per day in the reactors. This was due in turn to varying numbers of animals and variations in the volume of fish ensilage available. Although fish ensilage only contributed 8-10% of total volume, it had a higher dry matter (DM) content and higher proportion of volatile solids (VS, % of DM), so its contribution to total VS was around 40%. In period 3 for the Åna plant (Table 1), methane production was low when only manure was used as substrate and also low compared with the production rate observed for Åna substrate in the laboratory [14]. Using fish ensilage as co-substrate contributed to high specific methane production, which also resulted in increased energy production. The variation in retention time resulted in variation in the amount of energy produced in a pattern which did not follow that of specific methane production. Consumption of electricity represented almost 50% of the heat consumed, with colder periods clearly resulting in higher heat consumption (Table 1). The energy was used both for heating new substrate and to compensate for heat losses. The reactor had no insulation on the top cover sheet and this was probably the main reason for the high heat consumption.
The data also indicated that it would be wrong to use a set percentage of energy produced for calculating the internal energy usage, since consumption is dependent on the losses of energy, and not on the energy input. Compared with results from Germany [5], the energy consumption in the Åna plant as a percentage of energy produced was much higher, but the specific energy consumption was more similar to results reported for farm-scale plants in Sweden [6],[11].

Table 1

Energy production and consumption (average per period) in the one-reactor Åna plant in SW Norway in periods 1-3

			Period 1 (week 36-39, 2009)	Period 2 (week 49-53, 2009)	Period 3 (week 49-52, 2010 and week 1-2, 2011)
Hydraulic retention time		Days	31	26	28
Volatile solids (VS) from fish ensilage		% of total VS	46	35	0
Specific methane production		m3/kg VS	0.355	0.223	0.122
Energy production		kWh/week	11,900	14,800	5,600
Energy consumption	Electricity	kWh/week and m^3 reactor	4.1	4.4	3.6
		% of methane produced	8.5	8.4	18.1
	Heat	kWh/week	2,095	5,350	3,892
		kWh/week and m^3 reactor	8.4	19.1	13.9
		% of methane produced	30	42	70
	Total	kWh/week and m^3 reactor	13	24	17
		% of methane produced	27	45	88

Compared with Åna, the hydraulic retention time in the Tomb plant was shorter in all periods and especially in period 4 (Table 2), where it was only approximately half the retention time at Åna. The food waste substrate contained less VS than the fish ensilage and, although the input ratio based on mass was higher, the percentage of VS was lower for all periods. This is attributable to the higher concentrations of protein and fat components in fish ensilage than in the food waste used in the Tomb plant. The shorter retention time in the Tomb plant combined with moderately high specific methane production resulted in higher energy production than in the Åna plant. The electricity consumption was low for all periods but the heat consumption was higher in colder periods, which was expected since the heat losses were higher in these periods. There were problems during the recording periods, which can be summarised as:

– Too small capacity of the burner, which caused loss of biogas from the reactors if the production became very high.

– Too little biogas storage capacity. This meant that the burner had to run when the gas was available and not only when there was demand for energy.
– The plant had seven different heating pipes and these all interacted with each other. Controlling the heating of the reactors was therefore difficult.

Table 2

Energy production and consumption (average per period) in the twin-reactor Tomb plant in SE Norway in periods 1-3

			Period 1 (week 16-20, 2012)	Period 2 (week 45-50, 2012)	Period 3 (week 5-10, 2013	Period 4 (week 11-18, 2013)
Hydraulic retention time		Days	18	23	21	15
Volatile solids (VS) from food waste		% of total VS	22	31	30	30
Specific methane production		m3/kg VS	0.186	0.268	0.263	0.261
Energy production		kWh/week	14,871	12,932	12,565	17,056
Energy consumption	Electricity	kWh/week and m^3 reactor	1,6	1.8	2.0	1.9
		% of methane produced	3.2	4.2	4,7	3.3
	Heat	kWh/week	6,000	7,125	7,822	6,678
		kWh/week and m^3 reactor	20	24	26	22
		% of methane produced	41	55	62	39
	Total	kWh/week and m^3 reactor	6,469	8,864	9,681	8,444
		% of methane produced	45	59	67	42

Overall, these results show that increased retention time in small-scale reactors also increases the specific methane production, as shown here for the Åna plant. This could also lead to lower emissions from final storage of the bioresidues. On the other hand, it also resulted in much lower total energy production per week, which is a critical shortcoming.

CONCLUSIONS

The conclusions from analysis of the data from these two farm-scale biogas plants were that:

– Heat consumption in anaerobic digestion plants is high in the Norwegian climate. Net energy production could be increased by using co-substrate/s. This is probably essential for the economic viability of farm-scale plants.

– A large proportion of the energy produced is used to heat new substrate. A heat exchanger would reduce the energy demand substantially.

– Some of the energy produced is used to compensate for heat losses in the reactor. In both plants studied there was no insulation on the top cover. Investment in a well-insulated cover is strongly recommended.

– Comparing energy consumption in the two plants, the Tomb plant had the highest heat consumption per m^3 reactor. Good design of the reactor is essential for minimising heat consumption and maximising net production of GHG-neutral energy.

– Increasing the hydraulic retention time resulted in higher specific methane production, but decreased energy production. There was a tendency for this to result also in decreased net energy production.

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INSPECTION OF SPRAYING EQUIPMENT IN USE IN GREENHOUSES IN NORWAY

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Abstract. *Surveys indicate that spray application in greenhouses may be insufficient in many ways. Firstly, a wide range of different equipment are in use, which makes it difficult to apply a uniform dose. Secondly, the plant type, density and size may differ in the same house and even on the same plant table. Studies have also stated that the pesticide label is insufficient and difficult to transform into practical use. When not used properly, considerable deviations in uniformity of dose may frequently occur and the operator exposure may be high. Finally, several applications on a limited area may increase the risk of pesticide point pollution. Thus, an adapted program for inspection of spraying equipment in practical use in greenhouses including the focus on correct calibration and environment friendly application, is in progress. This inspection will be based on the forthcoming ISO 16122-4 'Fixed and semi-mobile sprayers', which is under development.*

Key words: *concentration, dose, calibration, environment, exposure.*

INTRODUCTION

In total there are almost 1,000 greenhouses in Norway and the average size is 2,000 m^2. The number of greenhouses above 5,000 m^2 has increased approx. 40% during the last 20 years (SSB, 2007). About the half is production of ornamentals, and the rest is different kinds of vegetables, mainly tomatoes, cucumbers and lettuce.

From 1997, all users of pesticides in Norway, including those in greenhouses, have to be educated in the correct use of pesticides. The Department of Mathematical Science and Technology at the Norwegian University of Life Sciences (MST) was responsible for the technical part due to spraying equipment and correct use. The wide range of equipment and methods in practical use was studied in advance, and secondly adapted teaching material had to be developed. In Norway all users of pesticides are obliged to renew their spraying certificate every 10 years, therefore several users have already renewed their certificate.

For crop sprayers and orchard sprayers in use, an inspection is compulsory every five years (Bjugstad et al, 2004). During such an inspection, the user of the sprayer has to join the test, and the inspector normally visits the different farms or orchards in order to carry out the inspection together with the user/owner of the spraying equipment. In this way, the grower gets an increased knowledge and motivation, which make him able to perform the application correctly. Additionally, the grower/user is skilled about how to calibrate his specific sprayer(s) by the use of a certain checklist. Hereby the grower/owner is able to fill in his own measurements and is encouraged to carry out this test by himself before every season. Additionally, an inspection is carried out by an inspector every five years, and simultaneously the technical information may be refreshed and updated. Finally, the user should participate in the earlier mentioned authorisation course every 10 years, covering all aspects dealing with the use of pesticides.

When developing an inspection program for spraying equipment in greenhouses, the positive experiences from the inspections and conditions in orchards ought to be implemented. Our experience is that when a grower meets the insepctor alone instead of attending a compulsory authorisation course where 20-40 people may be gathered, he gets a better adapted knowledge of spraying technique as well as an increased motivation to obtain a more precise and safer application. This is especially important in greenhouses, where the use and type of spraying equipment vary in a large extent as well as the type, size and density of the plant canopy.

Because of these positive experiences, the MST and the Norwegian Food Safety Authority find it important to include a similar calibration process in a forthcoming inspection of spraying equipment in greenhouses. For these applications in particular, procedures to carry out a correct calibration are unavailable. Therefore, the MST has studied the use of different spraying equipment in use for several years and suggested methods and procedures to ensure the correct dose. This paper will describe what kind of sprayers that are in practical use in Norway, experiments carried out in order to study the differences in spraying quality and biological results, and finally how to obtain an easy and exact inspection including calibration of the sprayers used in greenhouses. The proposed inspection also will take the forthcoming ISO 16122-4 'Fixed and semi-mobile sprayers' into account. (The author has access to the drafts of the standard still not published. Among others, he participates in a Nordic meeting twice a year where all upcoming standards within spraying application are discussed and evaluated. If others in the Nordic Baltic countries are interested to participate in these meetings, please contact the author.)

SPRAYING EQUIPMENT IN PRACTICAL USE AND THEIR LIMITATIONS

Table 1

Estimated use of spraying equipment in greenhouses in Norway

Equipment	Pressure range	Estimated use
High pressure equipment	5.0 – 15.0 MPa	45 %
Low pressure equipment	0.5 – 5.0 MPa	30 %
Spraying booms	0.2 – 0.8 MPa	5 %
Knapsack sprayers, knapsack mist blowers, small pressure sprayers, others	0.1 – 1.0 MPa	20 %
Cold foggers		Minor use
Spraying robots		Minor use, but increasing

<u>High pressure spraying equipment.</u> The high pressure system consists mainly of a trolley sprayer with a tank size from 25 to 300 litres, a drum with a 50-100 m long hose with a spray gun/ pipe/ boom and nozzle(s) at the end. The trolley is normally positioned at one of the ends of the houses. Then the hose and spray gun is pulled out in the length of the house or row normally without spraying. Afterwards, the operator sprays the house, tables or rows when he slowly moves backwards with a minimum of resistance when pulling the hose back. The working pressure of the nozzles is normally 5 to 15 MPa which is almost up to 100 times higher than for a conventional crop sprayer.
The advantage of this equipment is the possibility to adapt a dose and amount of fluid according to different plant size, which often differ in each house. The extraordinary high pressure makes it possible to spray over a longer distance, which means that the operator does not have to move all over the house as much as for the low pressure equipment later described. The disadvantages are mainly that the operator may be highly exposed of pesticides and that the labour costs are high. This type of equipment is much in use in Sweden and Norway today.
<u>Low pressure spraying equipment.</u> The low pressure sprayers are built in the same way as the high pressure unit, but the pump is smaller and the pressure range is normally from 0.5 to 1.0 MPa and in some extent up to 5.0 MPa. This equipment may also be used together with a spraying tower or vertical boom, i.e. in cucumbers, in order to get a more even distribution and easier handling of the equipment. Because of the lower pressure, the operator ought to walk between all the tables. The main advantages are low equipment costs and optimum adapted spray amount and dose due to plant size and type.
<u>Spray booms</u>. In large greenhouses, several plants have installed horizontal spraying booms. The main advantages of this equipment are a more even distribution and reduced labour costs. Additionally, a higher capacity is important in order to spray the plants in time and make the area ready for other work needed. However, several growers point out that the lack of adapting the spray volume easily due to different plant height along the similar swath, insufficient penetration through plant canopy as well as unwanted sprayed areas i.e. in the inter row, empty parts of the tables, spots outside the table etc. make these booms difficult to use properly for such conditions. For these reasons the MST has observed large plants where spray booms have been mounted in the house from the start, but are often not in practical use. However, if the problems mentioned may be solved easily, the spraying booms will be used more in the future than they are today. There are also possible to use manually pulled spraying boom equipment to lower costs, however these are not used in Norway at the moment (Foqué, 2012).
<u>Others (knapsack sprayers, knapsack mist blowers, small hand operated sprayers).</u> The MST has carried out operator exposure measurements earlier, which proved that the use of knapsack mist blowers results in a very high operator exposure and should be avoided if possible (Bjugstad & Torgrimsen, 1996). In

the ‘90s, the use of hot and cold fogging equipment was very popular in Norway. Thus, the MST made several deposit and operator measurements as well as biological studies together with other institutions. In table 2 some biological results are presented (Stenseth, 1992).

Table 2

Biological results when using a cold fogger vs. a hydraulic sprayer (Stenseth, 1992)

Pesticide	Application	Dose/concentration	% dead nymphs
Applaud	Wanjet Tornado ULV	50 g per 1000 m^2	32.0-82.0 %
Applaud	Hydraulic sprayer	0.05 %	100%
Thiodan 35	Wanjet Tornado ULV	200 g per 1000 m^2	34.5 – 55.8 %
Thiodan 35	Hydraulic sprayer	0.15 %	94.0 - 100 %
Dedevap	Wanjet Tornado ULV	360 g per 1000 m^2	15.8 - 29.9 %
Dedevap	Hydraulic sprayer	0.10 %	24.3-70.5
No treatment	Wanjet Tornado ULV		2.4-3.6 %

Experimental house size: 12 x 17 m^2
Applaud buprofezin, 230 g/kg, Thiodan 35 – endosulfan 357 6/l, Dedevap – diclorvos 500 g/l,
Nymphs: *Bemisia tabaci*

From the evaluation of hot and cold foggers and the biological results obtained, the following conclusions for such equipment were made compared with a conventional hydraulic sprayer:

- Poor effect for contact pesticides
- High risk of pesticide residues on products
- Dependant of pesticide properties
- Sensitive for breakdown of equipment
- Poor penetration and deposit on lower side
- Not possible to treat limited areas/ plants
- Deposit on greenhouse constructions

\+ High capacity due to high concentration
\+ Low weight
\+ Good effect where vapour effect is needed
\+ Might be run during the night
\+ Good operator safety for stationary equipment

- Poor operator safety for mobile wearing units
- High noise for combustion engine foggers
- Not to be used in food production
- Difficult to make inspection

Thus, the use of fogging equipment is forbidden in use for food production in Norway, and only approved for a few pesticides for ornamentals, where conventional methods are not sufficient effectively. The movable hot fogging machine is not recommended to be used due to safety reasons.

PROPOSED CONTENT OF AN INSPECTION FOR SPRAYING EQUIPMENT IN GREENHOUSES

The proposed requirements are based on the ISO 16122-4 ‘Fixed and semi-mobile sprayers’ draft and experiences made during the inspections of crop sprayers and orchard sprayers in Norway. Basic requirements as no leaks and a proper function are included for all kinds of equipment. However, the requirements, from our point of view, to some extent ought to be modified for different kinds of sprayers.

The calibration of the flow rate as well as the volume rate and dose of pesticide are misleading in greenhouses in Norway today. Thus, the MST highlights the focus of exact calibration and proper use of all sprayers and the importance of implementing this calibration training into the sprayer inspection. From our point of view, the correct use of equipment and dose of pesticide is often more important that the technical test itself, especially for small sprayers and low and high pressure sprayers, which are mostly in use in Norway. If these factors are not included, equipment which has passed a technical control could still cause large dosage failures. If this calibration should be carried out later by somebody else, this would result in increased costs for the grower and possible misunderstandings. Probably the equipment then ought to be inspected again to ensure that it works properly before the calibration is performed.

The user will be demonstrated how to move the nozzle(s) arrangement to obtain an even coverage and how to rapidly estimate the penetration and deposit. Additionally, the importance of walking backwards, where this is suited, is included, as well as other efforts to avoid a high risk of exposure, which may occur during the spraying operations (Bjugstad & Torgrimsen, 1996; Nuyttens et al, 2004). The spray result will be demonstrated by using water sensitive paper or non toxic dye stuff to examine how to obtain a good deposit and coverage.

On the label of the most fungicides and insecticides in greenhouses today in Norway, a concentration, e.g. 150 ml per 100 litres spray volume, is written. The original idea of this kind of labelling was that the operator was instructed to spray until run off. In this way, the volume rate and dose was easily adjusted for different plant sizes. However, this is correct only if different growers apply approximately the similar spray volume to the same plant type & canopy & density. During the last 20 years the MST has detected considerable variations in applied practical doses between different growers, in spite of carrying out the application at equal conditions due to similar pest attack, plant type and growth stage. In table 3 some results from 1993 are presented (Bjugstad, 2007). The users of pesticide in greenhouses were randomly divided into two groups, A and B. One operator was chosen and asked to spray until run off. The trial included large plants covering a floor surface of 70 m^2. The sprayer set up, nozzles, pressure used and other conditions were similar. In spite of this, the second group used 77% more fluid than the first group. Regarding the wetness of the plants from the first spray application, this group was expected to use a lower volume rate in order to obtain run off.

Several similar experiments have been carried out later for different plants and equipment. In all these experiments the volume applied differed in the range of 50 to 100% or more between different groups. This is caused mainly by the different visual assessment of run off which is very difficult to evaluate in a uniform and proper way.

Table 3

Variations in dose caused by using different volume rates in similar conditions

	Group A **Low pressure sprayer**	**Group B** **Low pressure sprayer**	**Group C** **Knap sack blower**
Litres used	13.0	23.0	1.36
Plant surface	70 m^2	70 m^2	70 m^2
Litres per 1000m^2	185	328	19.4
Dose in %	**100%**	177 % (+77%)	10.5 % (-89.5%)

Additionally, the movement of the nozzles, the distance from nozzles to plants, the walking speed or long/short legs etc. may influence the applied rate and distribution. It is also important to highlight that the growers are skilled not to use such a high amount of spray volume today, in order to avoid run off and get a better spray coverage. The users commonly also apply a much lower volume rate in order to increase the spray capacity.

The third group in table 3 used a knap sack mist blower. They applied a volume rate of only 10.5% of the rate of group A. This means that the average leaf area dose would vary from 10% to 177% if the concentration factor still remained the same. Thus, a concentration factor was introduced by the MST already from 1993. Additionally, we needed to implement a so-called normal volume rate corresponding to the factor 1.0, which was equal to the concentration on the label. However, this volume rate hardly did exist. Thus, the MST in 1993 introduced such rates in cooperation with a group of growers and biological experts in order to ensure that the use of different equipment and ways of application would result in an approximately similar leaf area dose. This was used by introducing the factors and values shown in table 4.

The volume rates in the table are for large plants and high densities. For smaller plants, reduced pest attack and lower crop densities the volume rates have to be reduced. In this way, the dose on the leaf surface per cm^2 almost will be the same in spite of differences of variations in plant size and density as well as by using different equipment and volume rates.

However, when we evaluated the situation afterwards, we experienced that the growers did not understand properly how to use this concentration factor and thus more or less used their former adjustments. The growers still use widely different volume rates for the same kind of application, which also result in large variations of the pesticide dose.

It is important to keep in mind that the biological efficacy depends on the amount of pesticide per cm^2 area of the surface of the plant. The quantity of water acts only as a carrier to transport the pesticide towards the aim and to ensure a sufficient coverage, and might, as presented in table 3, vary widely between different kinds of spraying equipment and for different operators treating the same kind of plants at similar conditions. The label should give information to all the users. However, most of the users feel their conditions are normal and apply the concentration given on the label for the sprayer and nozzles used without adapting any changes in the concentration factor. Slowly, the information on the labels have been improved. Combined with the forthcoming inspection of sprayers in use, a correct calibration to ensure correct dose will be included and improved. This is also highlighted in the authorization course material (Bjugstad et al, 2009).

Table 4

Concentration factor at different volume rates for selected crops

Concentration	Measured volume rate in litres per 1000 m^2		
Factor	Small flower plants/Lettuce	Roses	Cucumbers / Tomatoes
0.25	400	600	800
0.3	333	500	667
0.4	250	375	500
0.5	200	300	400
0.6	167	250	333
0.7	143	214	286
0.8	125	188	250
0.9	111	167	222
1.0	**100**	**150**	**200**
1.25	80	120	160
1.5	67	100	133
2.0	50	75	100
2.5	40	60	80
3.0	33	50	67
4.0	25	38	50
5.0	20	30	40
6.0	17	25	33
7.0	14	21	29
8.0	13	19	25
9.0	11	17	22
10.0	10	15	20

Professional greenhouse production results in a high number of applications on a limited area. Additionally, the floor may be of concrete and the risk of run off by dripping, cleaning or spraying outside the wanted area may cause a high risk of pollution. Thus, it is important to demonstrate by simple means how to avoid this kind of pollution. The solutions will depend much on the spraying system used, the building facilities etc. The inspector has to be aware of a possible contamination by the spray water used to carry out the inspection. If such a risk may occur, this water has to be collected back to the main spray tank. One problem is that long hoses are commonly used, which have to be well cleaned before the inspection can start. This is also a problem for the grower himself in practical use when a cleaning operation is needed. When using only one hose, the rinse volume may be collected easily. However, when starting to spray again, the initial spray will be too much diluted because water still remain in the system. This can be avoided by using a separate collecting tank, but this may cause much work. Another solution is to use a double hose recycling system, which will be rather expensive. However, a very simple and cheap method is only to put the spray gun into the opening of the main tank and recycle the flush water or spray fluid back to the tank directly to obtain equal concentration. Depending on the kind of spraying equipment used, the best suited solution is to be demonstrated during the inspection in order to motivate and skill the grower in a proper cleaning procedures.

All growers get a four page check list which makes them able to carry out a simple and quick control and calibration of their own later on. The list shall cover all potential equipment, include examples of data and describe how to use water sensitive paper. Additionally, all the growers get a package of water sensitive paper included in the inspection for later use.

The proposed inspection for spraying equipment in greenhouses will mainly be focused on the use of different high and low pressure equipment and spray booms. Knapsack sprayers, knapsack mist blowers and small pressure sprayer units will have exemptions from compulsory inspection. This is due the costs and of practical reasons. However, knowledge about correct calibration is of high importance.

CONCLUSIONS

A wide range of different spraying equipment is in use in greenhouses today. Additionally there is a huge variation in type of nozzles, number of nozzles, movement of nozzles, speed etc. which leads to differences in applied volume rates to similar type of plants. For fungicides and insecticides, the amount of pesticide normally is given as a concentration. Thus, it is rather challenging to ensure a proper recommendation in how to apply a correct dose per cm^2 leaf surface at different conditions. In order to solve this, a check list has been used since 1993, containing all necessary information for different spraying equipment as well as teaching material in the authorization courses for the users of pesticides.

A compulsory inspection of sprayers in use in greenhouses is planned in Norway. Parallel an ISO standard, ISO 16122-4 'Fixed and semi-mobile sprayers', dealing with inspection on a European level, is in progress. An adapted inspection for Norwegian conditions will also focus on correct and simple calibration including the use of the check lists. Hopefully, this inspection can start already in 2016.

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FLEXIHEADER CAN REDUCE LOSSES AT HARVEST OF DRY FIELD PEAS (*PISUM SATIVUM*) AND BARLEY (*HORDEUM VULGARE*)

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Abstract. *Yield losses may occur at harvest of crosp that are lodged or have set seed close to the soil surface. These losses are generally accepted by farmers as a result of season, local weather conditions and lack of proper equipment. One possibility to reduce losses at harvest is to use flexible headers, i e headers with the cutterbar mounted on a flexible suspension allowing a stubble height of as little as 25-40 mm.The flexible header is not in use in Sweden partly due to lack of information on performance in crops such as peas and barley. This pilot study has shown that flexible headers can reduce losses at harvest substantially, in some cases by more than 95%. The study has shown an interesting potential for reduction of yield losses dby introduction of modern, internationally available harvest technology.*

Key words: *flexiheaders, yield losses, harvest technology.*

INTRODUCTION

In Sweden, the combines used for harvest of small grain, oilseed crops and legume crops such as peas and field beans are equipped with standard headers using rigid cutterbar. In general the standard header is able to harvest all crops with small losses in field. However, in case of a lodged crop or crops with seed setting close to the soil surface (beans and peas), the standard header may be less suitable. Often the header needs to operate 10-15 cm above the soil surface to avoid stones and thus either leaves some of the crop in the field unharvested or shatter seeds from the lodged crop on the soil surface.

Although technical solutions exists for harvest closer to the soil surface, only a handful of Swedish farmers have chosen to use headers able to operate close to soil surface.

Some typical reasons for not choosing harvest technique with minimized field losses is cost of investment, uncertainty of the benefits of the new technique and availability of headers on the market. In order to provide some basic data to farmers and agricultural research in Sweden, we conducted field trials using one type of flexible header for use in field peas and barley. The aim was to investigate if harvest losses could be reduced by flexiheaders compared to standard headers.

MATERIALS AND METHODS

Field experiments were carried out in the province of Skåne, southern Sweden, in 2013 and 2014.

Two types of headers were used; either the standard header of a Claas Lexion 750 TT or a flexible Cressoni-header from Italy intended for peas and soya beans (www.cressoni.it).

Two crops were chosen as test crops; standard field peas for feed or food purpose and barley for feed. The barley was fertilized with mineral fertlizers to induce lodging and was also lodged by hand to create an even stand of lodged crop.

At harvest the two types of headers were mounted on a Claas Lexion 750 TT. The combine was hired from a machine station providing the service of harvest in different types of crop. We used the same driver for both headers and the harvest operation was carried during one day. In each plot, six smaller areas of 0.25 m^2 each were used for assessing remaining kernels of peas and barley respectively on the soil surface after harvest. Peas of cv Clara was used (TKW 230 g) and barley of cv Odyssey (TKW 50 gram).

RESULTS AND DISCUSSION

In 2013 the flexiheader was tested in peas and barley, but in 2014 testing could be performed in peas only due to mechanical problems with the header.

In 2013 there was no significant difference between the number of reaming kernels in the peas trial (p=0.109) although there was a substantial difference between the number of remaining kernels of the standard header

(260 seeds m^{-2} or about 598 kg ha^{-1}) compared to the flexiheader (9 seeds m^{-2} or about 21 kg ha^{-1}). We noticed big differences in remaining seeds between plots due to unevenness in stubble height. The plant height was about 33 cm at harvest.

In the barley trial we obtained a significant difference ($p= 0.0367$) in number of remaining kernels between headers. The flexiheader reduced seed loss from 484 kernels m^{-2} (about 240 kg ha^{-1}) to 159 (about 80 kg ha^{-1}) which is equal to a reduction in harvest loss of 67%. The plant height was about 20 cm at harvest.

In 2014 harvest was performed on July 30th in peas only due to mechanical problems with the flexiheader. The loss at harvest was minimal with both the flexiheader (about 2 kg ha^{-1}) and the standard header (about 5 kg ha^{-1}), but due to unevenness between plots there were no significant differences, $p=0.46$. The plant height was about 45 cm at harvest.

CONCLUSIONS

It is clear that flexiheaders can reduce losses at harvest, especially when the crop is lodged or has seed setting close to soil surface. The reduction in peas varies depending on plant stand and probably by harvest technology and skills of the combine driver. We suggest that flexiheaders are tested in a wide range of crops, especially those with seed setting close to soil surface such as soya beans, dry garden beans (*Phaseolus sp*), clover, dry peas and vegetable seed of spinach.

A general use of flexiheaders can reduce losses at harvest substantially which is economically beneficial for the farmer and society.

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DEVELOPMENT OF AMS IN THE NORDIC COUNTRIES BETWEEN 1996 AND 2014

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Abstract. *Since the first farms with Automatic Milking System (AMS) started in the Nordic countries there has been a dramatic change in the development of both the milking technique and the general environment for milk production in those countries. The first three AMS farms started in Denmark in 1996 and now, almost two decades later, the total numbers in all Nordic countries is 4.293 (31/12/2014) and with 6.894 AMS boxes. In Denmark, Finland, Island, Norway and Sweden number of farms and no. boxes pr. farm is respectively 824 and 2.8, 904 and 1.4 , 125 and 1.2 , 1376 and 1.0, and 1064 and 1.7.*

The development in recent years is quite different between the Nordic countries. Especially interesting is the development in Denmark where, after the crisis in 2008, the increase has stopped and in 2012 the number of AMS farms and boxes went down. The main reason might be the big difference in dairy farm sizes within the Nordic countries with Denmark leading with 162 cows pr. farm, Sweden with 78, Iceland with 38, Finland with 34 and Norway with 21 cows on average and the total average for the dairy farms within the Nordic countries is 53 cows. When farms get bigger, other milking systems like fast exit milking parlor or rotary are more interesting. In the other Nordic countries the number of AMS farms is still increasing.

The estimated milk production in 2014, 3.453 million kg., from those Nordic AMS farms stands for 28,7% of the total milk production within those countries and furthermore that 27,8% of the cows within the Nordic countries are milked with an AMS. Despite the high ratio of both milk and cows only 16,3% of the dairy farms do have AMS in the Nordic countries but their size is much bigger than the once with other milking equipment: 91 cows on average vs. 46 cows on average.

Key words: *milking technique, Automatic milking system, milk production.*

REFERENCE

Nordic AMS statistics 2014, Unpublished data from NMSMt (Nordic Dairy Associations Committee for Milk Quality Issues, Technological Working group) (2015).

CONVERT BIOGAS TO METHANOL OR/AND DME

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Abstract. *Biogas is produced when organic material is broken down by means of microorganisms without access to oxygen. The gas mainly consists of methane and carbon dioxide and small amounts of steam, nitrogen, hydrogen sulfide and ammonia. Currently, the gas is used for production of heat and electricity or is being upgraded to e.g. fuel gas. In 2012, 26 farm based biogas facilities existed in Sweden, mainly based on manure, producing in total 47 GWh biogas (Statens energimyndighet, 2013). In these facilities the main part of the biogas was used for heat and electricity and only 1 GWh was upgraded. The reason why not a larger amount was upgraded is due to the economy. It is costly to compress and transport the gas, especially when the biogas production site is far from the commerce. One alternative to the present field of application can be to process the gas further to transportation fuels as methanol and di methyl ether (DME). The main advantages with methanol and DME compared to biogas are that it is easier to transport and that is can possibly be used as a fuel at the farm. Therefore, within the project Biogas Skaraborg that is run together with and through Hushållningssällskapet Skaraborg, it is of interest to evaluate the possibilities to convert biogas to primarily DME, but possibly also methanol. The aim with this report is to make a short and general literature survey in order to present available technologies and identify their possibilities and most important challenges for further consideration of this biogas upgrading route.*

A number of different processes for the production of methanol and DME from biogas/natural gas have been developed, which are covered in this report. Among these processes, only a few focus on small scale production. However, the small scale processes are under development and some of them are predicted to be commercialized in the near future. According to Oberon fuels the efficiency of their process from biogas to DME is about 55%, which means that a small scale production of biogas of 6-15 GWh would produce 3-8 GWh/year DME. However, the costs and energy consumption for this type of process are not known. Another producer of small scale plants is Gas Technology, which process, compared to the others, is not based on catalytic synthesis. They claim that their process is cheaper compared to the others but on the other side the efficiency is probably lower.

To be able to produce and use DME in small scale on the farm the following is needed, required that the technology is commercialized and cost efficient: studies on how the fuel works in tractors; production of new tractors with modified engine; solutions to be able to distribute DME locally on the farm and externally; and solutions to take care of excess energy in shape of electricity and heat etc.

ANAEROBIC DIGESTION OF SUNFLOWERS AND AMARANTHS SILAGES WITH CATALYST METAFERM

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Abstract*. Fifty-fourbiogas plants are working today in Latvia. There is need to investigate the suitability of various biomasses for energy production. Maize is the dominant crop for biogas production in Latvia. The cultivation of more varied crops with good economics and low environmental impact is thus desirable. One of the way for improving biogas yield in Latvia conditions is using biological catalysts. This paper shows results from anaerobic digestion of sunflowers and amaranths silagesusing new biological catalyst Metaferm. The digestion process was investigated for biogas production in sixteen 0.7 l digesters, operated in batch mode at temperature 38±1.0°C. The average methane yield per unit of dry organic matter added (DOM) from digestion of sunflower silage was 0.267 $l \cdot g_{DOM}^{-1}$ with Metaferm1 ml- 0.307 $l \cdot g_{DOM}^{-1}$ and with Metaferm 2 ml-0,434 $l \cdot g_{DOM}^{-1}$. Average methane yield from digestion of amaranth silage was 0,403 $l \cdot g_{DOM}^{-1}$ with Metaferm1 ml- 0,602 $l \cdot g_{DOM}^{-1}$ and with Metaferm 2 ml-0,484 $l \cdot g_{DOM}^{-1}$. Both investigated silages can be successfully cultivated for energy production under agro ecological conditions in Latvia. Addition of catalyst Metaferm increased methane yield.*

Key words: *anaerobic digestion, sunflower, amaranth, biogas, methane, biological catalyst.*

INTRODUCTION

One of the most promising renewable energy sources is biogas. Biogas production must be developed, ensuring that methane collection also helps to implement the Kyoto Protocolprovisions. Latvian Action Plan envisages total electricity generation capacity of 92 MW [1] for the biogas plants in 2020. Number of working biogas cogeneration plants increase up to 54 in Latvia in 2014 [2]. There are around 369,000 ha of available land suitable for energy crops growing and the production of biogas in Latvia [3]. However, many of biogas plants are built in areas, e.g. in sub region Zemgale, with less or no free additional land areas for growing of biomass (mainly maize) for biogas plants. High cereals yields and increasing prices on grain in market can cause further decrease of maize areas, potentially limiting this traditional source for biogas production. Therefore it is necessary to find new biomass sources to stabilise or increase biomethane production in biogas plants in Latvia.

Common sunflower (*Helianthus annuus* L.) is annual plant, attached to *Asteraceae* family. *Helianthus annuus* ssp. *Sativus* Wenzl. is used for biomass production. In Latvia, the average biomass of this plant varies from 15.0 to 30.0 t ha^{-1}, but higher yield from 40.0 to 50.0 t ha^{-1} is possible to be grown in optimal agrometeorological conditions. The cultivation of forms and hybrids of this subspecies provides the raw material for biogas production during the whole season

Amaranth (*Amaranthus* L.) is annual or perennial plant, attached to *Amaranthaceae* family. There are more than 65 genus and about 900 species of amaranth in the world. About 17 species are used for food production. The most significant species are *Amaranthus. cruentus* L., *Amaranthus hybridus* L., *Amaranthus caudatus* L. Amaranth is one of the most productive plants. In fertile soils, the average fresh biomass is about 100 t ha^{-1}, the average seed yield varies from 2 t ha^{-1} to 5 t ha^{-1} (for seed varieties). The fresh biomass or silage of amaranth can be used for biogas production. [4].

Additional way to increase biogas production is improvement of anaerobic fermentation process itself. Currently, the biogas sector within some European countries is faced with the rapid development and innovation in usage of a variety of specific additives [5]-[8] aiming to increase the biogas yield.The aim of the study is to evaluate biogas and methane production from different energy crops silages, clarify whether the addition of biocatalyst Metaferm (made in Latvia) in substrates causes any positive effect, establish effective doses for optimised fermentation.

MATERIALS AND METHODS

In order to achieve greater statistical confidence the heated camera (Memmert incubator) and number of the small bioreactors were used. Small bioreactors were filled with substrate and placed in a heat chamber, and gas from each bioreactor was directed into separate storage bag located outside the camera. For obtaining of results the widely applied methods were used [9]. Dry matter was determined by investigation of initial biomass sample weight and dry weight by using scales Shimazu at 120°C temperature and by investigation of ashes content help by furnace Nabertherm burnt the samples at 550°C. All mixtures were prepared, carefully mixed and all sealed bioreactors were put in heated camera within same time period before starting of anaerobic digestion.Collected in storage bag gas composition was measured with the gas analyser GA 2000. Help by this instrument oxygen, carbon dioxide, methane and hydrogen sulphide were registered. Substrate pH value was measured before and after finishing of anaerobic fermentation process, using pH meter (PP-50) with accessories. Scales (Kern KFB 16KO2) was used for weighting of substrate before anaerobic processing and for weighting of digestate after finishing of fermentation process.Dry matter contents and ashes contents were measured for digestate from every bioreactor, to determine dry organic matter (DOM) content.
Each bioreactor with volume of 0.7 l was filled in with biomass sample 20 ± 0.05g and with 500.0 ± 0.2 g inoculum (fermented cattle manure from 120 l bioreactor working in continuous mode). For calculation purposes control bioreactors were filled only with inoculum. All data were recorded in the journal of experiments and into computer. All bioreactors were placed into incubator at operating temperature 38 ± 0.5°C, and every bioreactor have flexible pipe connected to gas storage bag positioned outside the heated camera. Every gas bag is provided with port, normallyclosed with tap, for gas measurement. Quantity and composition of gases were measured every day. Bioreactors were also gently shaked to mix the floating layer regularly. Fermentation process was provided with single filling in batch mode until biogas emission ceases. Final digestate was weighed, and dry matter and ashes were investigated to evaluate organic dry matter content. Total biogas and methane production values were calculated using the biogas normal volumes and quality parameters obtained from gas collected in the gas storage bag for each bioreactor.

RESULTS AND DISCUSSION

Results of raw material samples analyses for investigation of sunflowers and amaranths silages anaerobic digestion are shown in Table 1.

Table 1

Results of analyses of raw material samples before anaerobic digestion

Bioreactor/Raw material	pH substrate	TS, %	TS, g	Ash, %	DOM, %	DOM, g	Weight, g
R1, R16 only inoculum (Ie) 500g	7,52	5,09	25,45	19,62	80,38	20,46	500
R2,R3 20gSS	4,5	16,45	3,29	10,42	89,58	2,95	20
500g Ie + 20g SS	7,35	5,53	28,74	18,57	81,43	23,4	520
R4,R5 20gSS	4,5	16,45	3,29	10,42	89,58	2,95	20
500g Ie +20gSS + 1ml MF	7,46	5,53	28,74	18,57	81,43	23,4	521
R6,R7 20gSS	4,5	16,45	3,29	10,42	89,58	2,95	20
500g Ie +20gSS + 2ml MF	7,49	5,52	28,81	18,52	81,48	23,47	522
R8,R9 20g AS	4,3	16,18	3,24	14,41	85,59	2,77	20
500g Ie +20gAS	7,3	5,51	28,69	19,03	80,97	23,23	520
R10,R11,R12 20g AS	4,3	16,18	3,24	14,41	85,59	2,77	20
500g Ie +20gAS + 1ml MF	7,39	5,51	28,7	19,03	80,97	23,24	521
R13,R14,R15 20g AS	4,3	16,18	3,24	14,41	85,59	2,77	20
500g Ie +20gAS + 2ml MF	7,42	5,5	28,71	18,97	81,03	23,26	522

Abbreviations: Ie – inoculum; SS – sunflowers silage; AS – amaranths silage; MF – biocatalyst Metaferm; TS – total solids; Ash – ashes; DOM – dry organic matter; R1-R16 numbers of bioreactors.

Results of digestate analysis after finishing of anaerobic digestion process are shown in Table 2.

Table 2

Results of digestate analysis for sunflowers and amaranths silages

Bioreactor/Raw material	pH	TS, %	TS, g	Ash, %	DOM, %	DOM, %	Weight, g
R1Ie	7,30	4,18	20,62	24,30	75,7	15,61	493,2
R16 Ie	7,24	4,16	20,48	24,24	75,76	15,52	492,4
R2 SS+Ie	7,23	4,25	21,69	21,17	78,83	17,10	510,4
R3 SS+Ie	7,24	4,28	21,84	21,28	78,72	17,19	510,2
R4 SS+Ie+1ml MF	7,20	4,27	21,90	23,91	76,09	16,59	510,6
R5 SS+Ie+1ml MF	7,19	4,54	22,98	22,17	77,83	17,89	506,2
R6 SS+Ie+1ml MF	7,22	4,20	21,30	24,68	75,32	16,04	507,2
R7 SS+Ie+2ml MF	7,17	4,73	23,84	20,30	79,70	19,00	504,0
R8 SS+Ie+2ml MF	7,18	4,66	23,59	21,84	78,16	18,43	506,2
R9 ZS+Ie+2ml MF	7,16	4,52	22,97	23,12	76,88	17,66	508,2
R10 AS+Ie	7,19	4,10	20,80	25,14	74,86	15,57	507,2
R11 AS+Ie	7,23	4,26	21,53	25,16	76,84	16,11	505,4
R12 AS+Ie+1ml MF	7,14	4,58	22,92	21,41	78,59	18,01	500,4
R13 AS+Ie+1ml MF	7,26	4,63	23,24	21,91	79,09	18,38	502,0
R14 AS+Ie+2ml MF	7,20	4,64	23,51	22,71	77,29	18,17	506,6
R15 AS+Ie+2ml MF	7,23	4,61	23,08	24,16	75,84	17,51	500,7

The production of biogas and methane from sunflowers and amaranths silages and from control bioreactors is presented in Table 3.

Table 3

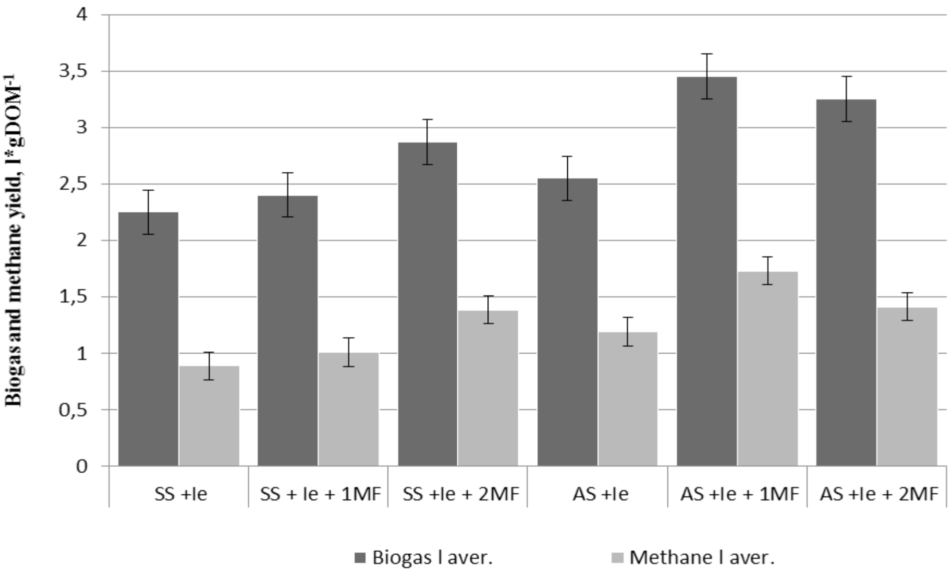
Production of biogas and methane in bioreactors from sunflowers and amaranths silages

Bioreactor/Raw material	Biogas, l	Biogas, l g_{DOM}^{-1}	Methane average, %	Methane, l	Methane, l g_{DOM}^{-1}
R1 Ie	0,9			0,110	
R2 SS +Ie	2,2	0,423	62,88	0,886	0,266
R3 SS +Ie	2,3	0,457	58,42	0,889	0,267
R4 SS + Ie + 1MF	2,1	0,389	62,46	0,819	0,243
R5 SS + Ie + 1MF	2,4	0,492	62,19	1,006	0,306
R6 SS + Ie + 1MF	2,7	0,593	62,90	1,202	0,373
R7 SS +Ie + 2MF	2,8	0,627	63,48	1,275	0,398
R8 SS +Ie + 2MF	2,8	0,627	69,22	1,382	0,434
R9 SS +Ie + 2MF	3,0	0,695	67,63	1,488	0,470
R10 AS +Ie	2,7	0,648	65,74	1,253	0,426
R11 AS +Ie	2,4	0,537	70,76	1,127	0,380
R12 AS +Ie + 1MF	4,0	1,129	59,34	1,913	0,670
R13 AS +Ie + 1MF	2,9	0,722	73,82	1,541	0,533
R14 AS +Ie + 2MF	2,8	0,685	60,72	1,226	0,416
R15 AS +Ie + 2MF	3,7	1,019	54,17	1,593	0,552
R16Ie	1,0			0,093	

Note: Biogas and methane values for biorectors R2-R15 with fresh source biomass are provided with already substracted average biogas and methane values obtained from reactors R1 and R16.

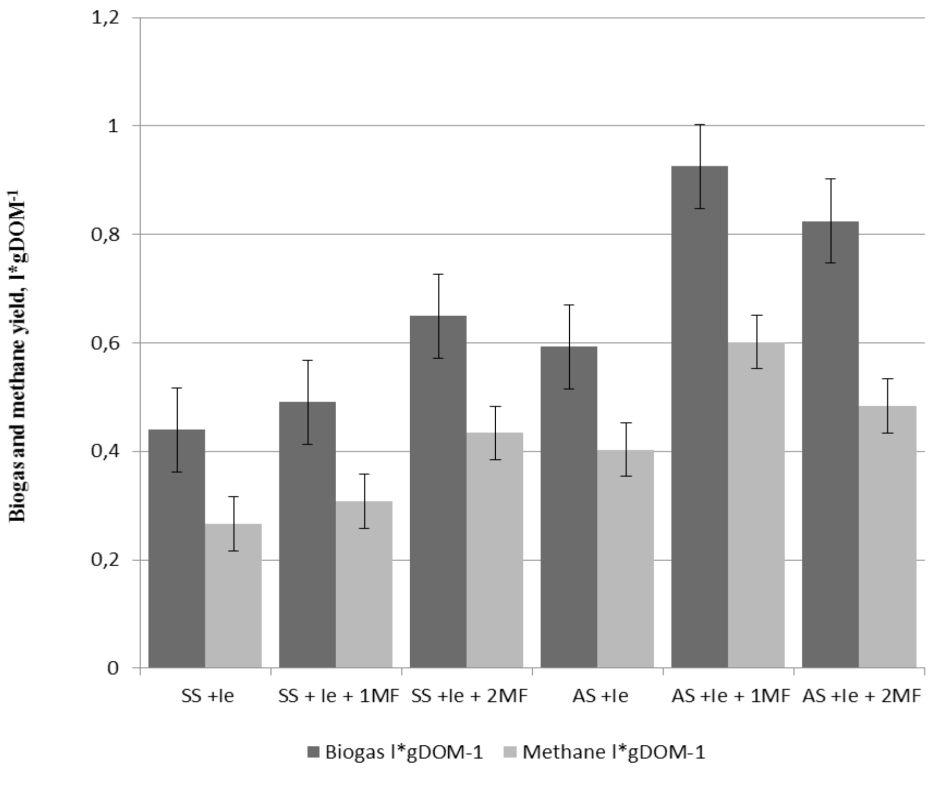
Abbreviation: l g_{DOM}^{-1} – litres per 1 g dry organic matter added (added fresh organic matter into inoculum)

Addition of biocatalyst Metaferm resulted in considerably higher methane production compared to control reactors (with sunflowers or amaranths silages only) in all bioreactors .
Average biogas and methane yield in liters from sunflowers and amaranths silages when added MF 1 ml and 2 ml shown in figure 1.



Abbreviations: Ie – inoculum; SS – sunflowers silage; AS – amaranths silage; MF – biocatalyst Metaferm; DOM – dry organic matter.

Figure 1. **Average biogas and methane yield in l from sunflowers and amaranths silages when added MF 1 ml and 2 ml**



Abbreviations: Ie – inoculum; SS – sunflowers silage; AS – amaranths silage; MF – biocatalyst Metaferm; DOM – dry organic matter.

Figure 2. **Specific biogas and methane yield (l*gDOM^{-1}) from sunflowers and amaranths silages when added MF 1ml and 2 ml.**

Specific biogas and methane production l*gDOM^{-1}volumes calculated for added sunflowers and amaranths silages is shown in figure 2. Very high methane yield when added 1 ml MF was surprise. Maybe it is explained with more amaranth seeds in these samples. There more research are needed.
Results show that for sunflowers silage higher yield with addition 2 ml Metaferm, but for amaranths silage 1ml Metaferm addition is good enough. It can be explained with higher fiber content in sunflower silage.

CONCLUSIONS

Addition of biocatalyst Metaferm have positive impact on fermentation process in all substrates compare to control without MF addition.

Addition of biocatalyst Metaferm in doses of 1 ml and 2ml gives rise methane production by 15.11%, and 16.25% in substrates with sunflowers and by 49.37%, and 20.09% in substrates with amaranths silages compare to control substrates respectively.

Methane yield from amaranths silage was 50.94% higher than from sunflowers silage.

ACKNOWLEDGEMENTS

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A REVIEW OF MOBILE ROBOTICS FOR AGRICULTURE

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Abstract. *A lot of attention is focused on the development of agricultural robots nowadays. The primary tasks of such robots are navigation in agricultural territory and do specified activities (plant inspection, spraying, harvesting etc.). Progress of mobile agricultural robot technology at this moment and future possibilities in the field of automation of agricultural activities are summarized in this paper. Today commercial usage of mobile robots in agricultural land management and crop cultivation is very limited with some exceptions e.g. lawn mowing. Manufactures also offer to customers variety of products that cover only selection of functions for mobile robotics: mobile platforms, manipulators, image recognition modules, spraying etc. But the supply lacks a complete robotized solution for example, spraying or pest inspection robot. Many scientific institutions are working on the development of mobile agricultural robots. Some of research directions are self localization and navigation in territory, route optimization, multi robotic systems, distribution of tasks, recognition technology (crop plants, pest, weeds, etc.), mechanical solutions for grabbing a piece of fruit or vegetable, transport and other smaller fields. In this study authors offer a classification of agricultural mobile robots using type of tasks, dimension, energy consumption and other criteria. Also this study summarizes the main problems that arise in the automation of agricultural tasks in comparison to controllable and relatively predictable industrial environment. As an example, the camera usage for vegetable recognition in spraying applications, where high light sources of high intensity or spray chemicals may come to the camera lens. The mobile robots in the agriculture is expected to continue to grow and get more cost effective.*

Key words: *mobile robots, agriculture.*

ASSESSMENT OF THE EQUIPMENT FOR CONDITIONING OF THE ENERGETIC BIOMASS

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Abstract. *Herbaceous energy crops would be the main basis for solid bio fuel production in agricultural ecosystem in future. Until 2014 the share of biomass as a fuel in Latvia is 29.2%, which is the highest percentage in the enlarged EU. To the 2020 Latvia has a target for renewable energy resources to be 40% in gross final consumption of energy. In this research are summarized Latvia university of Agriculture (LLU) projects about straw, hemp, reed, reed canary grass and peat mixture briquettes and granules parameters and machinery for it development. It is mentioned, that heating value of herbaceous biomass like straw material is slightly lower than it is for wood. In previous research carried out in LLU Institute of Mechanics was stated that briquettes are more durable if biomass mixtures with peat is used. However briquettes without peat content aligning axial direction in press die is necessary. For conditioning solid herbaceous biofuel where made several equipment – belt feeders, briquettes presses and extruders, belt type dryer, straw and bale shredders. As machinery complex it is design to use pneumatic transport between segments. Also equipment was made for easy transporting, meaning that machinery dimensions are suitable for transporting on main roads. Dimension restriction has negative effect on bale shredders pneumatic transport system. Energy losses in pipelines are reason for clogged transportation system. The energy for particle transporting is reduced with sharp bends and friction on pipeline walls.*

Key words: *Biomass, machinery, herbaceous material, peat content, fuel.*

FORESTRY

EUROPEAN ASH AND ELM DEVASTATED BY ALIEN INVASIVE PATHOGENS: PERSPECTIVES?

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Abstract. *Currently, severe Ash Dieback (ADB) is observed in most European countries. This is an emerging disease caused by invasive alien fungus Hymenoscyphus pseudoalbidus originating from Far East Asia. The disease results in massive ash mortality, and currently threatens the existence of tree species on a continental scale. Also Dutch Elm Disease (DED) is a lethal disease, which during the last 100 years has led to a massive mortality of elm trees in Europe, threatening the existence of the species over large geographical areas. DED is caused by invasive alien fungi from the genus Ophiostoma originating both from Asia and North America. But, data from clonal seed orchards of ash have demonstrated that different tree genotypes exhibit different levels of susceptibility to ADB. Reports from numerous countries indicate that there are individual ash trees without any symptoms in otherwise ADB devastated areas. Due to the fact that the massive amounts of pathogen spores are distributed by wind, all ash in such areas must have been about equally exposed to the disease. Therefore presence of symptomless ash would suggest tolerance or resistance to the disease. Consequently, breeding programs of ash against ADB have been recently initiated in many European countries. Moreover, it has been known for decades ago that different elm genotypes are not equally susceptible to DED, and trials for breeding of elms against DED in Europe have historical roots. As a result, recently a number of DED-resistant elm clones were developed and registered for practical use. Therefore, the objectives are: i) to establish seed orchards by planting available resistant genotypes of ash and elm; ii) to initiate silvicultural trials by replanting resistant trees in affected ecosystems; iii) to monitor and map vital ash and elm in nature for future use in breeding; iv) to continue breeding for resistance against ABG and DED for more resistant genotypes; v) to propagate those genotypes; vi) to initiate the experiments for biological control of DED with viruses; vii) to investigate existence of such viruses in ADB fungus populations; viii) eventually, check detected for potential use in ADB biocontrol; ix) to continuously perform biodiversity studies in areas devastated by ADB and DED, and mediate the results to society; x) to conduct demonstration meetings and seminars for stakeholders and general public.*

Key words: *ash dieback, Dutch elm disease.*

POTENTIAL OF PRODUCING WOOD BIOMASS IN SHORT-ROTATION GREY ALDER (*ALNUS INCANA* MOENCH) PLANTATIONS ON AGRICULTURAL LANDS

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Abstract. *The paper describes the potential of producing wood biomass in short rotation tree plantations (rotation period 5, 10 and 15 years) on agricultural lands. The research is focused on managing naturally emerging grey alder (Alnus incana Moench) coppice on agricultural lands, following up its course of growth and estimating the volume of biomass to be recovered. Grey alder as a fast-growing specie is suitable for short-rotation plantation cultivation in sites of nutrient-rich soils (site index H20=12m). Coppice of grey alder between the age of 5 and 15 years may be cultivated as a short-rotation plantation with the biomass yield depending on growing conditions from 20 to 445 loose* m^3 ha^{-1} *and gross income between 189 and 4201 EUR* ha^{-1}. *In grey alder plantations of site index H20=12, H20=16 and H20=20 you may already at the age of 10 to 15 years harvest pulpwood (top diameter 7cm under bark), packaging wood and fuel wood; the amount to be obtained depends on the intensity of thinnings done in age class I. As follows from the results, the average volume of fresh biomass in one year-old untended coppice of grey alder varies from 1.43 t* ha^{-1} *to 11.15 t* ha^{-1} *with the mean shoot height Hv=1.4 m and highly variable number of stems per unit area. In two-year old stands this variation is from 5.27 t* ha^{-1} *to 28.50 t* ha^{-1} *with the mean stem height Hv=2.5 m; in three-year old stands – from 7.95 t* ha^{-1} *to 36.60 t* ha^{-1} *(mean height Hv=3.0 m); in four-year old stands – from 18.83 t* ha^{-1} *to 52.80 t* ha^{-1} *(mean height Hv=4.4 m); in five-year old stands – from 22.91 t* ha^{-1} *to 64.23 t* ha^{-1} *(mean height Hv=4.8 m).*

Key words: *grey alder, naturally moist biomass, average height, number of trees per ha, productivity.*

INTRODUCTION

Over the past decades research on cultivating forest crops for energy wood has received increasing attention mainly due to the need to substitute fossil fuels for those recovered from renewable resources. In the boreal forest zone grey alder (*Alnus incana* (L.) Moench) is one of the fastest-growing species which yields both timber assortments and energy wood. In Latvia, between the 1930s and 2010 the area of grey alder stands has increased significantly because of abandoned farmlands taken over by forest [2]. This process is still ongoing, and according to the 2014 data of the Statistical Bureau the area under grey alder is as high as 210700 ha (stock volume 30.3 million m^3), which accounts for 11.4% of the total forest area (www.csp.gov.lv). In the Nordic countries, in 1980-1990s extensive research was carried out on cultivating grey alder and Salix species for wood chips.

In 2005-2009, the Latvian State Forest Research Institute Silava (LSFRI Silava) performed research on the potential of using grey alder coppice for short-rotation cultivation of energy wood (rotation for 5, 10, and 15 years). As proved by the results, grey alder appears to be a superior species for short-rotation plantations: 1) high productivity in a relatively short period; 2) no need for additional soil improvement due to symbiotic nitrogen fixation (actinomyce *Frankia*); 3) high resistance against unfavourable climatic conditions, diseases and pests; 4) coppicing ability which entails considerably less investments in stand regeneration and protection; 5) relatively simple stand management [2], [3].

In Sweden, Finland, Estonia and elsewhere a number of scientists have attempted determining mathematically the amount of biomass produced by grey alder stands, using regression equations with one or two variables – the DBH and tree height, as well as the mean diameter or stand basal area, determined on the basis of sample plots [4],[9]. In Latvia, significant studies on the productivity of grey alder stands have been done by a number of scientists [8], [5], [3]. In the mid-20th century P. Mūrnieks graphically developed the growth and yield tables for grey alder using the traditional methodology based on the data obtained from 80 sample plots measured once [8].

Recently J. Bisenieks and M. Daugavietis proposed mathematical models for determining the growth and yield of Latvian grey alder stands [3].

O. Miezīte has studied the problem of determining the biomass volume of sapling stands by using regression equations with a single variable – DBH, and the stand basal area – for calculating the volume of above-ground biomass in untended grey alder stands [7]. To calculate the biomass volume of sapling stands the LSFRI Silava researchers used regression equations with a single variable – the shoot height [1].

Some pilot experiments of initial fertilization of grey alder plantings as SRF (short rotation forestry) started at 2011 demonstrate, that fertilization of grey alder with wood ash could decrease increment [6].

The 2009 Cabinet Regulations No. 139 with amendments of 12.03.2013 provide for EU fund-supported short-rotation plantation cultivation of *Salix*, *Populus* and *Alnus* species in agricultural lands without undergoing the procedure of land use transformation (www.lad.gov.lv). The 2014 amendments in the Law on Rural Development define the concept of the plantation of woody plants as a definite-purpose establishment in regular patterns and longer-term cultivation of woody plants (except fruit tree orchards, tree nurseries and ornamental planting) in agricultural lands with the maximum rotation period of 15 years, followed by the crop regeneration or cultivation of farm crops other than woody plants. The above statutory provisions prove that Latvia is determined to pursue the course of using renewable resources for energy.

The goal of the research is to determinate the productivity of grey alder stands with and without tending and to develop a practical method for obtaining the source data necessary for calculation of the biomass of uncultivated grey alder stands aged 1 to 5 and 5 to 15 years.

MATERIALS AND METHODS

To determine the biomass yield in 10-15 year-old grey alder coppice stands sample plots were established and the related measurements made using the methods practiced in forest statistical inventory. Depending on the number of stems in the stand, three types of circular sample plots were set up: 100 m^2 with all stems measured; 500 m^2 with all stems measured; and 500 m^2 with the stems measured in three sectors depending on stem diameter. In all sample plots following measurements were made: diameter of all stems; height of 15-20 stems for calculating the height curve; width of the last 5 annual growth rings by using increment cores from 20 sample stems. In each sample plot increment cores were also taken from 10-12 sample stems for determining the stand age. Totally 42 sample plots were established and measured. For data processing and calculating the stand parameters, three mathematical models were developed and used in the *Excel* format – one for each type of sample plots. The formulas of I. Liepa were used for calculating of stem volume and the reduced current stand volume increment (1),(2):

$$v = 0.7450 \cdot 10^{-4} L^{0.81295} d^{0.06935 \lg L + 1.85346}, \tag{1}$$

where: v – grey alder stem volume (m^3) with bark;
L – stem height, m;
d – DBH, cm.

$$Z'_M = 12732.4 \Psi H^{\alpha} D^{\beta \lg H + \varphi - 2} [\frac{Z_H(\alpha + \beta \lg D)}{H} + \frac{Z_D(\varphi + \beta \lg H)}{10D}], \tag{2}$$

where: Z'_M – reduced current actual stand volume increment, m^3 (m^2)$^{-1}$;
H – average height, m;
D – average diameter, cm;
Z_H – current increment of average height, m;
Z_D – current increment of DBH, mm;
$\psi = 0.7450 \cdot 10^{-4}$, $\alpha = 0.81295$, $\beta = 0.06935$, $\varphi = 1.85346$.

For determination of the above-ground biomass of young grey alder stands, 15 stands of grey alder aged 1-5 years were selected, and the biomass of 3 stands in each age group with an area of at least 1 ha was measured.

In young grey alder stands after every 10 m a circular sample plot (radius 1m; size 3.14 m²) was established following the transect method with the sample plots accounting for 3% of the area. A total of 145 sample plots were established, in which all stems were measured, determining the root collar diameter $D_{root\ collar}$ (cm) of each grey alder stem, and the height H (m); the diameter was measured with a caliper (HAGLOF, Sweden; accuracy ±0.1 cm), the height – with a measuring pole (SK SENSHIN Japan; accuracy ±1 cm). Each stem was cut down, defoliated and weighed using the KERN sales (accuracy ±2g), thus obtaining the biomass (stem + branches) of each stem.
The number of tree stems per 1 ha was calculated using the following formula (3):

$$N = \frac{n1 + n2 + n3}{npl} \cdot 3185, \qquad (3)$$

if the sample plot radius R = 1 m,

where: $n1, n2, n3 ... nx$ – number of tree stems in individual sample plots,
npl – number of sample plots.

The average stand height was calculated using the following formula (4):

$$Hv = \frac{h1 + h2 + h3 .... hn}{h1 * n + h2 * n + h3 * n + ... hn * n}, \qquad (4)$$

where: Hv – average stand height, m
$h_{1,} h2, h3 .... hn$ – height of saplings measured in sample plots, m
n – number of repetitions.

The biomass of grey alder per 1 ha M (kg ha^{-1}) was calculated using the following formula (5):

$$M = 0.0536 \cdot Hv^{2.2516} \cdot N, \qquad (5)$$

where: Hv – average grey alder height, m;
N – number of trees per 1 ha [1].

The data processing and confidence calculations were done following the methods of mathematical statistics by using the *Microsoft Office Excel 2013*, and calculating the parameter mean values, standard deviations and relative errors – by using the SPSS software.

RESULTS AND DISCUSSION

As the field data show, the growth of grey alder differs depending on the growing conditions. In nutrient-rich and adequately drained soils (site index H20=20) the growth of gray alder in age class I is only slightly behind that of hybrid aspen.
For grey alder on the sites of higher site index the standing volume differs considerably. As it follows from Table 1, in higher site index sites (H20=12-20) the yield of stem wood already at the age of 15 years may be as high as 77-178 m^3 ha^{-1} [1].
It is to be noted that in unfavorable growing conditions (site index H20=8) the performance of gray alder is poor and there is no reason for cultivating it on such sites especially as a short rotation crop.
Previous and current studies on the natural regeneration of grey alder show that it coppices abundantly on the sites felled in winter [5],[2].
Depending on the site type, the number of stems in coppice growth varies from 33 360 per ha^{-1} (*Oxalidosa* site type) to 220 000 per ha^{-1} (*Mercurialiosa mel*). In *Aegopodiosa* and *Oxalidosa* site types grey alder stems account for 67% of the total with this index up to 95% in *Hylocomiosa* site type. With stem dimensions increasing their number per unit area decreases and the competition among them declines with age. In two-year grey alder coppice the number of stems declines in *Aegopodiosa* by 16% on average, in *Mercurialiosa*

mel – by 46 %, in *Hylocomiosa* – by 30%, in *Oxalidosa* – by 25% [2]. In subsequent years the number of grey alder stems in three-, four- and five-year stands falls compared to the previous year by 15-20% on average, while in adequate ambient conditions (light, moisture, etc.) it continues to develop basal shoots (Table 2).

Table 1

Productivity of Grey alder stands per ha

Age, years	Tree stem height, m	DBH, cm	Number of tree stems per ha	Volume of medium tree stem, m^3	Yield, $m^3 \cdot ha^{-1}$	Biomass, loose m^3 (0.4 t naturally fresh)
Site index H_{20}=8						
5	2.7	2.3	10000	0.0008	8	20
10	4.8	4.1	5192	0.0038	20	50
15	6.5	5.7	3539	0.0096	34	85
Site index H_{20}=12						
5	4.1	3.4	8000	0.0024	19	47.5
10	7.2	5.9	4251	0.0108	46	115
15	9.8	8.2	2937	0.0262	77	192.5
Site index H_{20}=16						
5	5.4	4.5	6000	0.0050	30	75
10	9.7	7.8	3302	0.0230	76	190
15	13.1	10.8	2328	0.0554	129	322.5
Site index H_{20}=20						
5	6.8	5.8	4000	0.0097	39	97.5
10	12.1	10.0	2339	0.0436	102	255
15	16.4	13.8	1709	0.1041	178	445

Table 2

Average number of stems, growth parameters and biomass in cutovers in 1 to 5 years after logging

Age of grey alder saplings, years	Number of trees per 1 ha	Diameter of root collar, cm	Height of trees, m	Weight of trees, kg
1-year	70 000	0.91±0.21	1.38±0.45	0.066±0.058
2-year	56 000	1.67±0.42	2.5±0.58	0.33±0.13
3-year	44 100	2.49±0.59	3.04±0.64	0.72±0.35
4-year	38 500	2.94±0.63	4.38±0.64	1.32±0.61
5-year	35 000	4.07±0.53	4.81±0.54	2.09±0.72

When comparing the data obtained in the given research with those of Swedish and Estonian [9] scientists, it is concluded that the number of grey alder stems decreases by an average of 20% in the second year, and by 37% in the third year, compared to the initial number of stems per hectare.

Field measurements show that the distribution of grey alder stems in young, naturally regenerated and untended coppice stands is highly uneven as, due to the effect of various factors (light, density, competition by grass and other tree species, skidder routes, etc.), the grey alder shoots up in groups, and therefore the number of stems in biomass measurement sample plots (size 3.14 m^2) varies considerably – from 0 to 30 or more stems.

The study results show that the biomass of young grey alder stands (1-5 years old) can be calculated with sufficient confidence by measuring the mean height and the number of stems per unit area, as in one- and two-year old stands we cannot determine the DBH at the stem height of 0.8-1.3 m [1].

The results of calculation of the biomass of young grey alder stands are summarized in Table 3.

As research data shows, the average volume of fresh biomass in one year-old untended sapling stands of grey alder varies considerably from 1.43 t ha^{-1} to 11.15 t ha^{-1} with the mean stem height Hv=1.4 m and a highly variable number of stems per ha (Table 3). In two-year old stands this variation is from 5.27 t ha^{-1} to 28.50 t ha^{-1} with the mean stem height Hv=2.5 m; in 3-year old stands – from 7.95 t ha^{-1} to 36.60 t ha^{-1} (mean height Hv=3.0m); in 4-year old stands – from 18.83 t ha^{-1} to 52.80 t ha^{-1} (mean height Hv=4.4m); in 5-year old stands – from 22.91 t ha^{-1} to 64.23 t ha^{-1} (mean height Hv=4.8m (Table 2).

Table 3

Above-ground biomass fresh of young grey alder stands (age 1-5 yr.), t·ha^{-1}

		Number of trees per ha				
age of stand, years	**average height of trees, m**	**10000-15000**	**30000-40000**	**50000-60000**	**65000-70000**	**95000-100000**
1-year	1.4	1.43	3.39	6.58	7.72	11.15
2-year	2.5	5.27	13.49	24.27	28.50	
3-year	3.0	7.95	22.29	36.60		
4-year	4.4	18.83	52.80			
5-year	4.8	22.91	64.23			

It may be concluded from the research data that in order to achieve a high biomass volume in grey alder coppice thinnings ought to be done no later than at the age of two years, thinning high density groups of saplings to achieve an even distribution of stems over the site and taking out undesired undergrowth trees and shrubs (especially aspen, and also bird cherry, willow, buckthorn).

Taking into account the current market prices of wood chips www.csb.gov.lv), gross income from one ha of grey alder short rotation plantation at the age of 15 years may be as high as 4 201 EUR ha^{-1} (Table 4).

Table 4

Cost-efficiency of Grey alder plantations

Age of stand, year	**Grey alder**		**loose m³ (0,4 t dry matter)**	**Gross income, EUR (8+VAT EUR·b.m³)**
	V, m^3ha^{-1}	SM, t.ha^{-1}		
5	8-30	3.4-12.9	20-75	189-708
10	20-102	8.6-43.9	50-255	472-2407
15	34-178	14.6-76.5	85- 445	802-4201

The research data also show that by cultivating grey alder on nutrient-rich sites (site index H20=12; H20=16 and H20=20) already at the age of 15 years it is possible to obtain not only wood chips but also fuel wood and pulpwood assortments (top diameter under bark 7cm) (www.kronospan-riga.lv/, http://www.db.lv).

In Latvia, the 2014 price level for grey alder pulpwood varied between 17 and 31.80 EUR ha^{-1}, and for grey alder fuel wood – from 15.63 to 25 EUR EUR ha^{-1}. In lower site index stands grey alder could be cultivated for wood chips (price level for chips 8.00+VAT EUR per loose m^3).

CONCLUSIONS

Grey alder as a fast-growing tree species is suitable for short-rotation plantation cultivation in sites of nutrient-rich soils (site index H20=12m).

5-15 years old grey alder coppice may be cultivated as a short-rotation plantation with the biomass yield depending on growing conditions from 20 to 445 loose m^3 ha^{-1} and gross income between 189 and 4 201 EUR ha^{-1}.

In grey alder plantations of site indices H20=12, H20=16 and H20=20 it is possible already at the age of 10 to 15 years to recover such assortments as pulpwood (top diameter 7 cm under bark), packaging wood and fuel wood; the amount to be obtained depends on the intensity of thinnings done in age class I.

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FACTORS AFFECTING HEIGHT GROWTH OF HYBRID ASPEN IN LATVIA

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Abstract. *Hybrid aspen (Populus tremula × P. tremuloides) has higher mean annual increment and shorter rotation period than other tree species growing in hemiboreal forests. It can be used for establishment of short rotation plantations to increase the availability of wood resources and increase the rate of carbon sequestration. Climatic changes are predicted to have an increasing effect on growth of trees. Therefore aim of our study was to analyse the intra-annual growth dynamics of hybrid aspen and factors affecting it as well as the effect of predicted climatic changes on growth of this hybrid. Weekly measurements of height increment were carried out through the growing season of trees in two plantations, consisting of 19 clones (10 ramets per clone), grown on abandoned agricultural land. Mean height growth period of hybrid aspen ranged from 119 days for late flushing clones to 137 days for early flushing and was tightly linked to total length of height increment i.e. was significantly higher for clones with early and intermediate leaf flushing then for clones with late leaf flushing. Mean growth intensity (ranging from 7.7 mm day^{-1} to 11.7 mm day^{-1}) was significantly affected by daily mean temperature, but not with other meteorological parameters. Influence of weather factors on height increment was weakest for early leaf flushing clones with. Both height growth intensity and consequently also annual height increment was significantly affected by clone. Results suggest that predicted rise of temperature might be beneficial for height growth of young hybrid aspen in Latvia, however, increased evapotranspiration in combination with changes in precipitation regime and presumably also groundwater level might limit the positive effect. Clones with early leaf flushing in general had a higher annual increment and lower sensitivity to meteorological parameters and therefore can be recommended for establishment of plantations in future.*

Key words: *height growth intensity; height increment; tree growth; short rotation plantations.*

NEEDLE CAST DAMAGES IN YOUNG SCOTS PINE STANDS

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Abstract. *Climatic changes are predicted to improve the conditions for fungi, therefore increasing the probability of infection and severity of damages for forest trees. Needle cast has affected young pine stands previously and now is one of the most important threats in forest nurseries. Therefore aim of our study was to analyse meteorological conditions affecting severity of damages caused by needle cast fungi (mainly Lophodermium sp.) as well as genetically determined differences of Scots pine in the degree of damages by these fungi. Three series of experiments were analyzed: 1) open-pollinated Scots pine progeny trial that consists of 226 families from 13 provenances of Latvia, established in two localities (Tukums and Kalsnava). In these trials needle cast damage (in 5 grade scale) in the second growing season and survival of trees was assessed; 2) control-crossed progeny trial that consists of 72 crosses from 10 parent trees, established in two localities (Zvirgzde and Kalsnava). In these trials needle cast damage (in 5 grade scale) in the sixth growing season was assessed and tree height, height increment and diameter of root collar measured; 3) open-pollinated progeny trial, established in Daugmale, that consists of 60 families from 5 provenances of Latvia. In this trial needle cast damage (in 5 grade scale) in the third, fourth and fifth growing season was assessed and tree height, height increment measured. Degree of needle cast damages had statistically significant effect on growth (height increment) and survival. Significant effect on degree of needle cast damages was found both for genetic and meteorological factors as well as for interaction between them. The average degree of needle cast damage in open-pollinated progeny trials was 4.7±0.01 in Tukums, 4.6±0.03 in Kalsnava and from 3.7±0.02 at the age of 3 years to 3.0±0.03 at the age of 5 years in Daugmale; in control-crossed progeny trial it was 4.6±0.02 and 3.4±0.04 in Zvirgzde and Kalsnava, respectively. In both experiments with more than one site significantly (p<0.001) lower degree of needle cast damage was observed in experiments in eastern Latvia – Kalsnava, where the average daily air temperature in August was lower than in other sites. There was a similar trend between years found in the experiment of Daugmale: warmer weather and/or higher amount of precipitation in previous autumn resulted in increased severity of damages in the next year. Therefore increasing needle cast damages due to predicted rise of temperature can be foreseen in future. The correlation between the degree of needle cast damage and growth traits was negative and statistically significant both at provenance and family mean level. Therefore selection of less affected families and provenances for forest regeneration material is suggested. Study was carried out in Latvian Council of Sciences project “Adaptive capacity of forest trees and possibilities to improve it” (No 454/2012)*

Key words: *resistance, forest tree breeding, adaptation, genotype x environment interaction.*

CHARACTERISTICS OF UN-MANAGED NORWAY SPRUCE STANDS IN WINDTHROW AREA IN SLITERE NATIONAL PARK, LATVIA

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Abstract. *Majority of forest areas in Latvia are or has been affected by human activities and there is lack of reference of un-managed forests. It can be assumed, that large-scale disturbance (like forest fire or storm) minimizes the effect of former forest management, and after its influence semi-natural stands emerge. Aim of our study was to quantify parameters of such stands forming after large-scale wind storm in absence of any management. Study site was located in north-western region of Latvia (57°38'N, 22°17'E), part of Slitere National Park that has been excluded from management activities since year 1923 and has been severely affected by wind storm in November 1969. Areas for the study were randomly selected from list of compartments in two forest sites types on fertile soil Myrtilloso-sphagnosa and Oxalidosa, where less than 10% of trees have survived after the storm based on forest inventory data. Circular sample plots with radius 12.62 m (area 500 m^2) were established in for stands on wet mineral soil (Myrtilloso-sphagnosa) and two stands on dry mineral soil (Oxalidosa), altogether 9 and 8 plots respectively. Tree height and diameter were measured for all standing trees, greater than 6.1 cm. Norway spruce was the dominant tree species (70-97% from total basal area) in both forest types independently from the dominant species (Scots pine, silver birch or Norway spruce) in the stand after the storm. Admixture consisted of silver birch, common aspen and black alder, but Scots pine was not present. Mean stand density was 1978 trees ha^{-1} and 1544 trees ha^{-1} on wet and dry mineral soils, respectively. The density corresponded to basal area of 18 m^2 ha^{-1} and 37 m^2 ha^{-1}, respectively and was notably and significantly higher than in managed Norway spruce stands at the same age, where, based on data from National Forest Inventory, the figures were 16 m^2 ha^{-1} and 23 m^2 ha^{-1}, respectively. Nevertheless, the diameter of trees was notably and significantly smaller in un-managed stands than in managed both on dry and wet soil (16.0±7.8 cm vs. 18.9±5.53 cm and 11.9±4.67 cm vs. 17.4±5.21 cm); also the diameter distribution differed significantly. Results demonstrate, that Norway spruce that is considered to be a climax species has a significant potential to regenerate after large scale natural disturbance on fertile mineral soils, forming dense young stands. Further studies shall analyse the age structure of these stands to assess the success of each establishment types: from advanced regeneration and from seeds. Study was carried out in European Social Funds (ESF) project "Management of vital Norway spruce stands: ecological and technological aspects" (No. 2013/0022/1DP/1.1.1.2.0/13/APIA/VIAA/052). Research permission from administration of Slitere National Park is acknowledged.*

Key words: *natural regeneration; Picea abies; storm; large-scale disturbance.*

EFFICACY OF BIOLOGICAL CONTROL AGENT ROTSTOP IN CONTROLLING *HETEROBASIDION* INFECTION IN SPRUCE AND PINE STUMPS IN LATVIA

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Abstract. *The biological control agent Rotstop®, used in controlling Heterobasidion annosum s.l. infection in conifer stumps by spores of Phlebiopsis gigantea (Fr.) Jül., was registered in Latvia in 2007 for use in thinnings of Norway spruce (Picea abies (L.) Karst.) and Scots pine (Pinus sylvestris (L.)). The efficacy of Rotstop in Latvian forests was analysed in six experiments conducted during 2005-2010. Observations were made in several months of the year. Sample plots were established in thinnings and final cuttings. Samples from experiments were collected after 1-12 months. In total 178 Rotstop treated stumps of Norway spruce and 130 stumps of Scots pine were analysed. Control stumps (133 spruce and 90 pine) were also sampled. Control efficacy against Heterobasidion spp. was calculated on the basis of number of infected stumps and area occupied by Heterobasidion spp. on sampled stumps. Mean efficacy in controlling natural infection by Heterobasidion in spruce stumps was 63% as calculated on the basis of infected stumps, and 89% as calculated on the basis of infected wood on sample discs cut from the stumps. The corresponding figures for pine were 82% and 95%. The results show that this biological control agent can be successfully used for stump treatment in Latvia, although improved efficacy is desirable. A Latvian strain of P. gigantea, selected from numerous isolates in preliminary tests, was used in one experiment, and it proved as effective as the Rotstop strain.*

Key words: *stump treatment, Rotstop, Heterobasidion.*

HETEROBASIDION ANNOSUM S.L. IN *PICEA ABIES* UNDERSTORY: INCIDENCE AND IMPACT ON RADIAL GROWTH OF TREES

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Abstract. *Norway spruce (Picea abies (L.) Karst.) is one of the most economically valuable tree species growing in Europe. As it is commonly affected by Heterobasidion annosum s.l., great effort has been made on research to understand the impact of H. annosum on trees forming the canopy, but information on its impact in Norway spruce understory trees is scarce. The aim of this study was to evaluate incidence, extent of decay column in stem and the impact of H. annosum on radial growth of Norway spruce trees growing in understory of Scots pine (Pinus sylvestris (L.)) stands in Myrtillosa and Hylocomiosa forest types. Data for this study was obtained from spruce trees growing in the understory of three pine stands (115 and 126 years old in Myrtillosa and 121 years old in Hylocomiosa forest types) located in Kalsnava (managed by LSFRI Silava and the LUA National Research Forest Agency 'Forest Research Station'). A total of 708 sample discs (508 in Myrtillosa sites and 200 in Hylocomiosa site) of spruce trees at stump height were obtained and tested for the presence of H. annosum. Later, for H. annosum infected trees on each plot, tree height, root rot height, diameters of tree with bark and without bark, root rot diameters at stump and breast heights were measured. Sample discs at breast height were collected to evaluate radial growth of the analysed trees. As a control, the same numbers of healthy trees with similar diameters at breast height were located within the stand and measured. Results show that the lowest incidence of H. annosum in examined understory spruce was 12.0% (24 trees) in the Hylocomiosa stand, the highest incidence was 29.5% (76 trees) in the 115-year-old Myrtillosa stand and in the 126-year-old Myrtillosa stand incidence of H. annosum was 16.4% (41 tree). Diameter increment at breast height of spruce trees in understory for the last five year (2005-2009) period was smaller for healthy trees than for infected trees in the Hylocomiosa stand (0.38±0.03cm: 0.40±0.04cm), while in Myrtillosa stands healthy trees had larger diameter increment than infected trees (0.44±0.03cm: 0.42±0.02cm). In both stand types the difference between diameter growth of healthy and H. annosum infected understory spruce trees was insignificant ($p>0.05$). Regarding spread of H. annosum in spruce stems, the average diameter of H. annosum rot at stump height was 5.9±0.3 cm (64.8±2.3%) in Myrtillosa stands and 5.7±0.4 cm (75.9±2.0%) in the Hylocomiosa stand. The ratio between diameter of rot at stump height and rot height in tree was 1:40.7±1.9 in Myrtillosa stands and 1:39.0±3.1 in the Hylocomiosa stand. This study showed that there was no significant difference in radial increment between understory spruce trees infected with H. annosum and healthy trees.*

Key words: *Picea abies, understory, Heterobasidion, radial growth.*

LANDSCAPE ARCHITECTURE AND PLANNING

THE INFLUENCING FACTORS OF LANDSCAPE AESTHETICS IN LATVIAN RURAL AREAS

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Abstract. *Latvian rural landscapes have changed rapidly through different historical periods. Nowadays, when globalization and the strong impact of technologies take place, the existing values of rural landscapes become even more threatened. Also the lack of a clear planning system has raised several problematic issues related to rural landscapes: loss of valuable agricultural lands (transformation into forest and building areas); losing landscape and heritage values; a non perceivable image and identity of Latvia. Thus for establishing the base for a new landscape planning system it is important to determine the main factors influencing the changes of Latvian rural landscape in different historical periods. The paper focuses on rural landscape aesthetics as one of the most important resources of Latvian countryside. The survey is based on scientific literature and historical materials as well as on the authors' research on present changes in rural landscape. The results highlighted that in the period before World War II, human economic activities were the main factors. In the Soviet period political and industrial factors came to the surface. The factors of changing human life style and using new technologies became dominating in the period after regaining independence in Latvia.*

Key words: *Latvian rural landscape, landscape aesthetics, historical review.*

INTRODUCTION

Rural landscapes are often associated with traditional landscapes of the definite region [1] because they represent nature processes, human activities and traditions of the region. Thus they are an important key in the recognition of the region`s landscape identity, and also the protection and preservation possibilities of rural landscapes are an important precondition for ensuring the diversity of European landscapes. In the globalisation era more often landscapes have "identical faces", and the regional singularity decreases rapidly [1]. Therefore the consideration of the regional context, mostly recognised by the rural landscapes, in territorial planning is an important aspect, since it is connected with sustainability of the regional landscape and protection of landscape identity. The preservation of landscape as well as the strategy for the development of landscape as a diverse resource thus also as an aesthetic resource, has been stated by The European Landscape Convention [2] which emphasises the specific importance and role of landscape for the creation of a qualitative space of life.

Landscape aesthetics. Aesthetics of rural landscape as an important recognizable element and resource of the country has been emphasised in several studies. A rural landscape also has a close relation to the historical development of the word *aesthetics*. The word aesthetics is connected with human perception and the concept of beauty, where one part has been developed in the human subconsciousness from nature's cognition time [3]-[6], but the second alongside with art and science trends has been reflecting the philosophy, traditions, way of life, the consequences of most important political and economic events, which are determined by the traditions and events of a definite time period [7].

The origins of landscape aesthetics have been found in the paintings of the 17-19th century in Europe [8]. Those reflected beauty of rural landscape, nature elements and rural peoples` life. Landscape aesthetics has been associated with the concept of *beauty* that significantly affects a person's emotions and feelings [9],[7], [10], the aesthetic categories besides beauty also include *sublime*, *pastoral* and *picturesque*. Statements of pleasant experiencing of landscape reflected in the work of the philosopher Edmund Burke (1757), describing the fascinating, gracefully formed 'beautiful' landscapes, as opposed to 'horrific', spacious and huge 'noble' landscapes. The philosopher Uvedale Price (1794) pointed out that the picturesque landscapes can recover 'listless beauty' and 'horrific greatness'. Thus picturesque emerged as a balance between those two opposite ideals. Pastoral in fine arts reflects an idyllic countryside landscape with cattle and shepherds. The concept of pastoral influenced literature, art and music by representing rural life in an idealistic way [9] and it was addressed mainly to people from cities. Based on it, a new direction of aesthetics – *Aesthetics of Nature* was established. This highlighted the ideas of beauty, majesty and picturesque of nature and its elements [11]. In the 19th century Aesthetics of Nature lost its importance, but in the second part of the 20th century it was revived again as *Environmental Aesthetics* and was influenced by the growing interest about environmental problems. Environmental Aesthetics deals with philosophical issues regarding not only the world as a unity, but also the human impact on the landscape, man-made environment and ecosystems [12],[13]. Steven Bourassa combined various theories of human perception and pleasure of landscape from pervious centuries and developed a new direction of aesthetics – *Aesthetics of Landscape* [14]. This direction includes a concept based on: processes in biological laws (historically developed person`s abilities and cognizance to arrange his/her surroundings for basic needs according to the experience from his/her ancestry); cultural rules (impact of traditions on a person`s experience of landscape aesthetics); and personal strategies (impact of temporal trends in landscape planning and design resulting as changes of a person`s surrounded landscape) [15],[16]. A relatively new one is the *Aesthetics of Everyday life,* which developed an independent direction from the Aesthetics of Nature during the last 40 years. Nowadays Aesthetics of Everyday life becomes leading in landscape planning because it is connected with daily activities, environment, things and objects but not so much with art. It explores not formal characteristics of things and objects to make them beautiful but the relationships between people and things or objects to develop this experience as pleasant and beautiful [17].

Latvian rural landscape. Aesthetics of surrounded rural landscape has always been an important element for Latvian people because of their historically close relations to the land and nature. Ancient Latvians as pagans organized their life according to nature’s rules, and processes in nature played an important role in their economic activities and everyday life [18]. Latvian rural landscape has undergone a lot of changes till its present image but still today Latvian people feel a strong attraction to the rural landscape. In the research of landscape perception concerning Latvian rural landscapes, questionnaires were used in different regions of Latvia [4],[19]. According to the findings the Latvian landscape identity at this period of time in society is associated with the traditional rural landscape, formed by the specific features of nature in different regions. The respondents – rural and urban inhabitants associated the countryside with pleasant feelings aroused by nature’s harmony, modesty, pristine nature and vastness, patriotism, a sense of identification and belonging to a place, and nice childhood memories through tales and pictures. Bell’s research [4] revealed that the most important aesthetic landscape elements were intact rural landscape, hay stacks, storks, thatched roof houses, bathhouses, old oaks in the middle of fields, old lime trees or oak alleys, tilled fields, farmsteads, winding country roads, hills and gardens in bloom. However, the processes of globalization inevitably promote the transformation of the regional identity of the historical landscape into new forms, determined by the changes in people’s life styles and needs, the arrival of new technologies and materials, huge urbanization processes, migration of people and the disappearance of national characteristics [21]-[24]. Each nation has its own life space, which throughout the centuries, has shaped its mental perception and historical traditions. In this way the environment obtains its cultural and historical value [25],[26],[4]. If the understanding of this concept is ignored, the national self-assurance of a nation is lost.

The European Landscape Convention [2] emphasises the importance of diversity of European landscapes as well as preservation of existing values of landscapes. Thus this research deals with rural landscape aesthetics as a valuable key element of Latvian national identity. The aim of this study is to determine the main factors influencing aesthetics of Latvia’s rural landscape in different historical periods and to compare them with the tendencies of the present development.

MATERIALS AND METHODS

The survey is based on scientific literature and historical materials as well as the authors’ current research on present changes of Latvian rural landscape. Mapping and photography methods in correlation with historical data analysis were used to estimate changes of landscape patterns and to assess the main factors influencing them.

There are main historical periods that were detected and used for the study. They are characterized by distinguishing patterns of rural landscape in Latvia: the period when the first Balts came, the period before the land reform in 1920, the period before World War II, the Soviet period and the period after regaining independence in 1990. Within each of these periods, the main processes which affected changes in the pattern of Latvian rural landscape were characterized and the main influencing factors detected.

RESULTS AND DISCUSSION

Results of the research are represented in Table 1. According to the results the main influencing factors of aesthetics of Latvian rural landscape were detected and divided into the following groups: nature processes; human perception, traditions, temporary trends and globalization; human`s economical activities and politics.

Table 1

Influencing factors of Latvian rural landscape

Historic periods	Processes affecting changes of landscape pattern	Influencing factors
1800 B.C. (the first Balts) – 9th Century	– Economic activities, use of materials in buildings based on nature resources found close to settlements – Clearance of forest areas for agriculture – base for mosaic landscape – Life style – living, working, celebrating according to the processes in nature	Human`s economic activities for basic needs Impact of processes in nature to everyday life and activities Human perception, cognition of aesthetics and beauty
10th-18th Century	– Improvement of tools – formation of traditional Latvian detached farm houses – Manors, castles – Reflecting of science development in nature – denying everything that existed in the past, new landscape elements reflecting human power over nature	Development of technologies
19th Century – World War II	– Land reforms – transformation of landscape scale – from large to small – Dividing or destroying landscape ensembles of manors	Politics
Soviet period (1940-1990)		
– Collectivization – Industrialization – Military areas	– Structural and visual changes of rural landscape – Transformation of landscape scale – from small to huge – Loss of differences – visual and social uniformity in urban and rural areas in different Soviet republics – Mental changes of landscape (deportation of native inhabitants, inflow of workers from Soviet republics)	Politics Human perception, changes of traditions
– Agricultural intensification – State farms	– Development and location of new alien landscape elements in rural areas – huge state farms, buildings – Denying of cultural heritage – functional, visual and social transformations of places	Human activities Human perception, changes of traditions
Independent Latvia (after 1990)		
– Privatization – Decrease of agriculture and manufacture (consumer life style)	– Structural and visual changes of rural landscape – Transformation of agricultural lands into building or forest areas – Natural afforestation of agricultural fields	Human economical activities
– Globalization	– New landscape elements – Loss of differences and local character – visual and mental uniformity in urban and rural areas in different places in Europe	Politics Human perception, changes of traditions

Nature processes. Changes in climatic conditions have played an important part in the shaping of Latvian landscape. They have caused the *composition of forest stands* as well as determined *human economical activities*, for example – type of agricultural production, arrangement of fields and farm houses etc. [27],[20],[18],[28]. During the Soviet period *changes in natural vegetation* and *composition of traditional* *agricultural plants* occurred. Local flora was affected by *invasive plant species* (hogweed, lupine, Jerusalem artichoke etc.) initially introduced and used as fodder. After regaining independence in 1990 and the collapse of the state farms it was possible to regain denationalized properties. But nowadays a great number of farms and lands are becoming abandoned because of people`s migration to the city or abroad. Thus nature takes over the former agriculture lands and *afforestation* takes place [4]. Also *climate change and flooding* is becoming an issue today because of the growing groundwater level and drainage systems not properly managed during the last 25 years.

Human perception, traditions, temporary trends and globalization. Results show that in the period, when the first Balts came to Latvia and started to use the land, aesthetics did not play the leading role in the life of ancient Latvians. Still in the Latvian Dainas [29] the first initiatives in the *arrangement of the living place and surrounded land* could be found and the development of *traditions* according to the ancient people`s cognition about the beauty of nature and its elements – the terrain, wind, odors, sounds and vistas [9],[18] could be traced. Nature elements, mostly plants and stones, played an important role in ancient people`s lives. They were *symbols, elements of worship and traditions* – oak – for strength, rowan – for repelling evil, apple tree – tree of Mother, etc. After the arrival of Christianity the importance of nature elements as symbols decreased. After World War II and during the Soviet period the denial of cultural heritage as well as traditions and symbols occurred. *Standardization* in arrangement of places and buildings led to the *loss of local singularity, landscape character and identity* [9]. After regaining independence in 1990 the role of ancient traditions and local landscape increased, but also the process of globalization started. Thus more and more identical landscapes and elements were created.

Human`s economical activities and Politics. Initially there were nature elements from the surrounding areas used in the arrangement of Latvian farmsteads and yards (wood, reed, clay, stones etc.) and all the economical activities were organized according to the processes in nature. One of the first changes in landscape was connected with economic activities, e.g., cutting down forests during the period of clearing woodland for farming, thus initially delineating the Latvian traditional mosaic landscape. Large forest areas were burnt down and cultivated for agricultural purposes alongside with the introduction of clearance crop-growing. The plots of land which were not cultivated afterwards, gradually were occupied by bush and tree species, thus changing the original vegetation type. At that period irrigation and drainage systems on agricultural lands were introduced [9].

Political activities and decision making also have important influence on economic activities and the development of rural areas. *Wars* had the most significant impact on changes of the landscape, for example, in the 17th century the cutting down of forests took place, because there was a high demand for timber for war purposes in Europe [19],[4],[28]. But the war factor should be excluded because it has emergency and exceptional character. The subsequent Latvian landscape transformation processes were influenced by several *land reforms* [25],[27],[18],[4]. As a result of the land reform of 1920 vast estate lands which occupied several hundreds of hectares were divided into smaller plots whose sizes were only several tens of hectares [25],[4], therefore the landscape obtained a new pattern that was characterized by *clusters of single farmsteads* in the rural landscape. From the year 1940, corresponding to the regulations of the land reform, the forests owned by farmers as well as the small plots of land on these areas with fields, meadows and pastures were handed over to forestry enterprises, as a result of which they soon became overgrown, since no cultivation was carried out. As a result of *collectivization, elements non-typical of Latvian rural landscape* appeared – rural settlements with urban type buildings and infrastructure, symbolizing equality between the countryside and cities [25],[20],[18],[4]. The people were moved from farmsteads to villages, and their lands were transformed into huge agricultural lands, which were adapted to agricultural production [26],[20],[4]. The next period of change in the Latvian landscape was associated with regaining of independence in 1990. It promoted different economic activities, *regaining of denationalized property*, and the single farmsteads came back into the rural areas again. However, during the Soviet period the people's traditions had changed, due to changes in their life style from the rural to the urban style. The national structure had also changed. According to the data of 1935 and 2014, after World War II the number of Latvians decreased from 77% to 61%, but there was an increase in the number of Russians – from 9% to 26%, Belorussians – from 1.4% to 3.4%, Ukrainians – from 0.1% to 2.3% [30]. These were the reasons why the main function of most of the farms was no longer agricultural activity, but the principle of the countryside was - the countryside as a living place and city – as a work and recreation place. This principle also lies at the basis of the creation of new housing settlements in the rural areas close to the larger cities and towns. Some farms and lands become abandoned even more because of people`s migration to the city or abroad, and afforestation takes place in those former agricultural areas [4]. Today political decision making becomes a more important factor. Many regulations and restrictions pertain to the agricultural sector. For example, the closing of sugar factories in Latvia in 2006 that affected the production of sugar beets which in turn affected the rural landscape pattern. Also *Energy landscapes* (lands with energy plants, biogas production etc.) have become a common image of the Latvian rural landscape.

CONCLUSIONS

During the Soviet period and at present political decision making and regulations become a more important factor. The factor of changing human life style (consumer life style) has become dominating in the period after regaining independence. As a result – afforestation of abandoned lands and transforming of some part of valuable agricultural lands into housing or forest areas have occurred.

Nowadays the landscape changes are more and more affected by new technologies in agriculture. Thus new and even non-typical agricultural production has arrived. Therefore the issue of aesthetical aspects should be solved at the national planning level, during the elaboration process of legislative documents.

The aesthetic aspects of landscape change are mostly affected by economic activities and the formation and management of households. Therefore those should be addressed at the regional and local planning levels with individual approaches and solutions.

The use of visually equal elements provokes uniformity of landscape (collectivization and industrialization in the Soviet period; globalization processes nowadays).

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CHURCH LANDSCAPES IDENTITY IN THE COASTLINE OF NORD KURZEME

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Abstract. *Church buildings are visually expressive dominants of the landscape; however, the sacral landscapes in Latvia have not been extensively researched. In order to reveal the character of church landscapes and its elements, a thoughtful selection of indicators and their scale is needed. A particular method of research has been employed for characterisation of the church landscape in Nord Kurzeme, on the shore of the Baltic Sea and along the bay, synthesized by a way of such specific research method as imageability*

Key words: *church landscape, identity, character, Kurzeme coastline.*

INTRODUCTION

The historical development and architecture of the landscape of Nord Kurzeme. The coastal territory has an interesting phenomenon – rather many villages, unlike the rest of the territory of Latvia. This is due to the harsh living conditions and occupation - it is not possible to fish in the sea, going alone, so the Kurzeme coastal fishermen chose to go to sea together and build common fishing facilities. Of course, living in the villages is a traditional way of life for the Livonians, but also coastal Latvians lived together. Times change and, due to the changed conditions of life and occupation, many villages were dissolved because people preferred life in farmsteads.

Religion and churches in Kurzeme. Christianity originally came in Kurzeme peacefully and gradually. A number of changes in the landscape and the culture as a whole started along with the arrival of the Christianity, for example, in North Kurzeme cremations that had previously been typically here had disappeared. Each region in Latvia developed differently. Kurzeme was hardly affected during the time of the Livonian and Polish-Swedish wars, therefore in the second half of the 16th century the pronounced formation of differences had already started in the Duchy of Kurzeme (Courland) [1],[2]. Although there were little churches in the beginning, then in the second half of the 16th century the decision was accepted to establish in Kurzeme 70 church congregations and build or rebuild churches there [1],[2]. Many of these churches have survived to the present day and are the national cultural monuments. In Kurzeme, unlike other Latvian culture-historical districts, Christianity was not the only one that was more pronounced in common. During the time of the Duchy of Kurzeme (Kurland) Christian church was represented by Catholics, Lutherans, reformists (Calvin's teachings followers), Orthodoxies and Old Believers [2]. In the beginning of the 17th century paganism still had a major role in the Latvian spiritual life. Latvians of Kurzeme tightly clung to the religion of their forefathers. The period of baroque of Kurzeme is characterized by the simple, ponderous external presentation appearance. In the beginning of the 18th century fever epidemic made a great distress to Kurzeme [1],[2]. In the 18th century Latvia was not still a united territory and different development continued in various different spheres of life in each of the culture-historical districts, including religion. During the Soviet period the restriction of the Christian traditions and atheistic propaganda took place. Landscape visual protection on the European level has become current along with an implementation of the European Landscape Convention. Ever since the middle ages the feature of populated area is the buildings of public nature, designed for people gathering, buildings for living and church along with the burial area – as the local religious focal point [3] both in the visual aspect and in the spiritual and planning form. It is limited information available about church landscapes; therefore the determination of the landscape character is included in the fixation of the current state.

MATERIALS AND METHODS

Objects. The research area is the North Kurzeme – from the city Ventspils to the city Mērsrags. The objects of research are located in the North Kurzeme coastal area the Lutheran, Catholic and Orthodox churches, as well as a Baptist prayer houses, hereinafter referred to as churches. The research includes 12 churches.

In year 2012 the Lielirbe Baptist Church building, which is nearly one hundred years old and once was located in Ventspils region, was moved to the Ventspils Seaside Open Air Museum. Starting with the Ventspils city the landscape of Nord Kurzeme seaside consists of territories included in the districts of Ventspils, Dundaga, Roja, Mērsrags. This territory is known as Livonian coast and typical by it's low population – small villages from Ventspils to Kolka, area that is away from motorway by Baltic seaside. Some part is also villages from Kolka to Mērsrags, by the motorway Tukums – Ķesterciems – Mērsrags – Kolka. Starting with from the city Venstpils the landscape of North Kurzeme seaside consists of territories included in the districts of Ventspils, Dundaga, Roja, Mērsrags.

Methods. Monographic or descriptive method, based on the existing as well as scientific knowledge and theory acquired during the research, was used for the theoretical foundation for the development, as well as for the compilation, the identification and interpretation of the results.

Several landscape research methods were used to characterize the church landscape of the coastline of Kurzeme: imageability method; descriptive inventory; definition of the perception criteria of the landscape visual overall image.

Imageability method. The characterization of church landscape of the coastline of Nord Kurzeme was carried out by the imageability method [4],[5]. Indicators of imageability in church landscape were defined during field surveys in 2012 and 2014 within the framework of the expedition, using aerial photographs as reference. An aerial photograph of the surveyed church landscape was prepared before going to the particular place. A detailed survey of each place was made on scouring the area and all access roads to analyze all the available viewpoints. The place imageability schemes of the landscape of particular churches where this method was used were made on the basis of aerial photograph to be able to clearly define the scope. On the other hand notably objects in the imageability schemes differ in which elements form the nature of the church landscape and landscape borders. Imageability schemes are made in „AutoCad 2012" programme, using a variety of graphical tools, as well as inserting there the aerial photo of particular church landscape.

Descriptive inventory. A fixation of church garden elements of the coastline of Nord Kurzeme, consolidation of the results and transformation to visual patterns were made by tying a quantitative method with a qualitative method. A descriptive inventory was used in the research of the garden landscape space and elements, which is widely used in the evaluation of visual resources [5]-[10]. Based on the experience of the previous research a matrix of survey and cartographic materials had been already prepared before the expedition using an electronic card system kurtuesi.lv. Survey matrix includes all the most anticipated parameters of the church landscape and elements of the church garden that would be useful for further research. On surveying the church gardens in the coastline of Nord Kurzeme, there were fixed elements existing in every church garden. Later data obtained in matrixes were summarized in the "Microsoft Office Excel 2007" program. The research focuses on the visible physical identity.

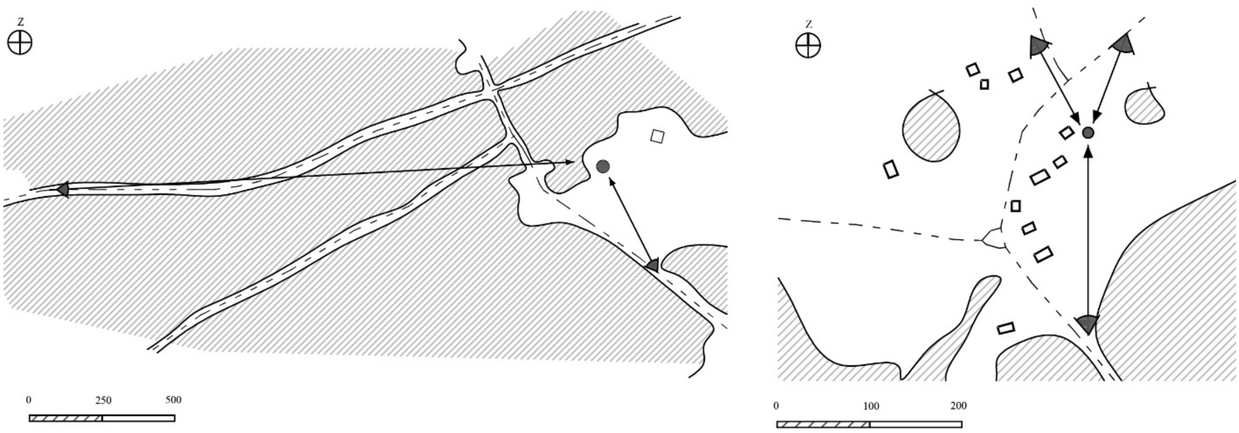
Perceptual criteria for the visual overall image of the landscape. Based on these theoretical visual perception levels of the landscape identity the visual survey matrix of the landscape was designed, which served as the data collection, surveying the research area. The survey matrix includes the total subjective visual evaluation of the landscape [9],[11]-[23]. There were determined following parameters for the subjective evaluation of the landscape: the visual availability, scale, topography, color, materials, texture, diversity, rarity, senses, movement, and natural landscape.

RESULTS AND DISCUSSION

In general churches in the coast are distributed irregularly, differently, both clustering around the populated areas, and locating in a rural landscape. Churches are found in all four research territory districts. In the district Ventspils there is one church located in North Kurzeme coastal area – Lutheran church of Miķeļtornis. There are five churches in the district of Dundaga coastal area – Lutheran church of Mazirbe, Baptist church of Pitrags, Lutheran, Orthodox and Catholic churches of Kolka. There are four churches in the district of Roja coastal area – Lutheran church of Ģipka, Lutheran and Catholic churches of Roja and Lutheran church of Kaltene. And from the district of Mersrags in research are included two churches – Lutheran and Baptist churches of Mersrags.

There are 12 churches in the survey territory in total, 7 of them are Lutheran churches, 2 Catholic churches, 2 Baptist churches and 1 Orthodox church. Most of observed churches are located in even though small, but still populated areas. Accordingly, other churches are located in the rural landscape, because large populated areas are not included in this research. The research area is divided into: "rural landscape" – territory outside populated areas, not excluding that there might be individual residential or non-residential buildings located next to the church, "rural populated area" – villages and small populated areas, small towns.

Imagibility is essential characteristic aspect of the church landscape. Factor that affects the visibility of the church is the height of the church building and expressiveness of the church building bell tower as a dominant in the landscape. All 12 churches of this research territory are above 6 metres, exceeding the height of the low-rise buildings. Churches are located in flat places as well as in relief. These factors influence that fourth part of the churches are visible from distance. The church landscape of the North Kurzeme is more visible and typical with massive church buildings. Half of the research territory churches are stone buildings with visible bell tower. In previous research territory – South Kurzeme more typical were miniatures church landscape spaces, where the church is not an expressive dominant, but often groups in the common building of the populated area, creating a single fishermen's' village landscape. Most of the church landscapes of North Kurzeme are placed in small cities or villages on side of the road.



a) b)

dominant point – church; viewpoints; tree structure;
main road axis; dwelling house

Figure 1. **a) Lutheran church of Mazirbe; b) Baptist church of Pitrags**

The church landscape of Mazirbe is clearly definable, because of the large scale and elements included, with a clear dominant of the church and as the second dominant is the pastor house. There are two long view lines, are almost 2 km and second 0.5 km. Background and coulisses are formed by seaside forest territories. Unique church landscape in context of other North Kurzeme research objects is Baptist church landscape of Pitrags. Unlike others it is low church building and fuses with surrounding dwelling houses. View lines are very short, not exceeding 100 m (Figure 1).

Occurrence of elements in the church gardens. Church landscapes and church gardens in the Latvian regions are formed according to different principles. These differences reproduce regionally different historical development and traditions. In general church gardens of the North Kurzeme have highly minimalistic nature. There are household buildings, sheds and outdoor toilets in the church gardens. Symbolic elements are met a little in these gardens. Often there are burials in or next to the church garden (Table 1). The same situation is with the decorative plants. Perennials and in only minimal amounts are only in half of observed church gardens. Most of the garden structures are asymmetrical.

The results of the percentage distribution of the occurrence of the elements in church gardens are rounded to the whole numbers to obtain greater transparency.

Table 1

The occurrence of elements in church gardens in the coast of the South Kurzeme

Nr.	Element	Occurrence of the element in the church garden, %
1	Fence	75
2	Small benches	75
3	Outdoor toilet	50
4	Burials inside the territory of the church garden	42
5	Woody perimeter	25
6	Crucifix	25
7	Household building	25
8	Well	25
9	Decorative facade lighting	8
10	Decorative pound	8
11	Children playground	8
12	Fireplace	8
13	Burials next to the territory of the church garden	8

Occurred trees. In the most of the church gardens we can found – pine, birch and lime trees. Quite often there is also lilac, maple and chestnut trees. Less we can see thuja, spruce trees. In few church gardens we can find rowan, oak, ash and apple trees. Pine trees are typical due to closeness of the sea. Trees such as linden, birch, maple are considered as a typical for the whole Latvian landscape. An interesting is application of the rowan in the church garden, which is placed at the entrance of the territory. It is considered for reverberation of sacred pagan traditions in a sacral garden area.

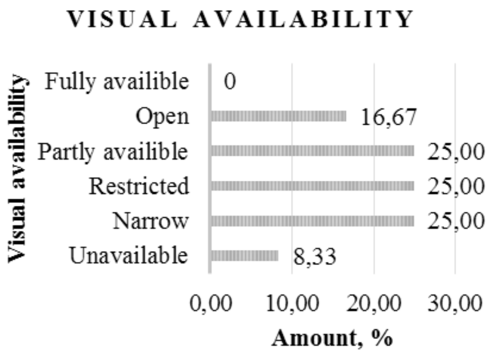


Figure 2. **Visual availability**

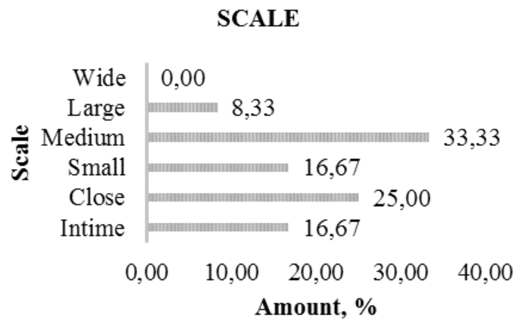


Figure 3. **Landscape Scale**

Figure 4. **Feelings**

Criteria of the perception of the visual landscape overall image. The visual availability of the coastal church garden landscape of the Nord Kurzeme after the results of the research is narrow (25%), restricted (25%) and partly available (25%), more rarely open and restricted (Figure 2). It is based on a coastal mosaic structures in rural areas or on a fully enclosed areas formed by coastal forests, as well as the small and medium scale of the churches. It is proved by the landscape scale after the results of the research which in 33,33% of cases is medium, 25% – close, 16,67% small and only 8,33% – large. (Figure 3). In addition this visual limitation is also explained by the churches located in flat areas rather than a flat hill tops that elsewhere in Latvia – 33,33 of cases the terrain is easy wavy and ~ 25% flat with some rolling hills. The coastal church landscape identity is also closely connected with the used materials, which here is represented by a brick (in 3 cases), wood (in 3 cases), plaster with stones (in 8 cases) and stone (in 7 cases). The texture of the landscape is generally rough (66%) and fine (34%).

The coastal church landscapes fundamentally are natural landscapes with some human-made elements (66%), because they are mainly located in rural landscape. Thus the landscape movement is also explained, which at the results of the research is defined as quiet (67%) or dead (25%). The prevalence of the natural landscapes and a distance of a people and civilization community created interesting (7 times), safe (5 times), enjoyable (4 times) feelings (Figure 4). On evaluating the coastal church landscapes they are defined as unique (16%) and typical (75%), which in turn is connected on the one side with the the tipical architecture with the tower to the most of the churches, but in return with a common readable elements that bring this typicality and common landscape features.

CONCLUSIONS

Church landscape of North Kurzeme is integral part of coastal landscape identity. Church building scale marks out and dominates in common landscape, but because of coastal forests they are not seen from very far viewpoints. Appropriate to architecture of Livonian fisherman villages – small scale wooden churches are not found in this territory, more we can find middle size stone buildings with typical church architecture, bell tower and burials inside the territory of church garden. These church gardens and burials are like extension of pine tree coastal forests, with separate birch, lime, lilac, maple and chestnut trees. Most typical garden elements are fencing, gates and benches. Common mood for church landscapes is interesting, safe and enjoyable, what is based on landscape closed space and middle scale, waved coastal relief and litle population with quite territory.

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PUBLIC OPEN SPACE REVITALIZATION IN CITIES OF LATVIA

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Abstract. *The vast changes in the past several years in Latvia and the other Baltic Sea region states have significantly affected the public open space. This type of situation is typical not only in Latvia, but occurs also in other cities of the Baltic Sea region states. These public open spaces structures with several thousands of residents take over vast city territories.*

Functional, aesthetically harmonious, and organised public open spaces can be achieved with a successful spatial composition. With the change of the lifestyle, there has also changed the understanding of the necessity of the public outdoor territory. In the European Union there are multiple examples of rational public open space revitalization, and their experience could be applied in the Latvia cities. For example, Jelgava is the largest city in the centre of Latvia, which is able to raise interest with its continuous transformations in the city landscape.

The waterfront of the Driksa river, which is located in the centre of Jelgava, and its beautiful landscape enriches the visual image of the city. The changes and transformation of the natural substrate are continuing all the time; it is one of the most significant places in the city of Jelgava. From the historical point of view, the analysed section of the Driksa river waterfront has experienced multiple significant transformations. Consequently, the research analyses the visual spatial transformations from the urban construction composition perspective which presently indicates the positive and negative aspects of the analysed territory, where a significant factor is also the present society's perception and opinions towards the analysed territory.

Based on the research materials and analysis of the modern cases, the aim of the research is – to analyse positive and negative aspects of public open space in cities of Latvia. To establish the current situation, in the process of research, the comparative method was applied. The method was used in order to obtain clear visual examples that would establish the positive and the negative aspects of the public open space.

SUSTAINABLE RURAL AND TERRITORIAL DEVELOPMENT

RURAL SPACE COHESION CHALLENGES

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Abstract. *Under the current conditions, the European Union is characterised by unbalanced development trends, as territorial disparities among the Member States and regions within the Member States increase owing to the effects of the economic crisis. In the result, the Territorial Agenda of the European Union 2020 emphasises that territorial cohesion is a common goal. The aim of the research is to formulate the territorial cohesion system of the Baltic States as a region of the European Union. To achieve the aim, two tasks are set: 1) to single out and describe the similar variants of territorial cohesion and their interrelation; 2) to justify the importance of internal disparities across the regions in Latvia to identify the challenges to be tackled for reducing these disparities. The description of the real situation is based on EU, FAO and Latvian statistical data, which were grouped, compared and analysed, and leads to the following conclusions: a/ territorial cohesion as a phenomenon and a process simultaneously involves four pathways for reducing disparities, starting with the highest level – the perspective concerning the European Union as a system as a whole – and ending with reducing local territorial disparities within any EU Member State; b/ internal disparities of the regions, their causes and forms and especially the ways of tackling them have been the focus neither for scientists nor for politicians, even though the disparities were significant. Since the municipalities forming the regions, in accordance with the ESPON methodology, are predominantly rural or intermediate territories, reducing the internal disparities of the regions, at the same time, contributes to wellbeing in rural areas as a space for life and work.*

Key words: *rural space, territorial cohesion, challenges.*

INTRODUCTION

The sustainable development of rural areas has been a key objective of the European Union's Common Agricultural Policy since it was formally established as the second pillar of the policy in 2000, with increasingly important budget allocations. In its early days, rural development policy was essentially sectoral (dealing mainly with agricultural structures), with limited territorial aspects. In the period 2007-2013, the CAP's objectives focused on improving the countryside and improving the quality of life in rural areas, while in the period 2014-2020 one of the priorities of the CAP was defined as fostering local development in rural areas (European Commission. Rural Development in..., 2013). Accordingly, the focus shifts from the average indicators for the entire European Union and individual Member States to the disparities, and cohesion-oriented policies are strengthened in the EU. Since 1986, the objective of cohesion policy has been to strengthen economic and social cohesion. The Lisbon Treaty and the EU's new high-level strategy (Europe 2020) introduce a third dimension: territorial cohesion.

Under the current conditions, the European Union is characterised by unbalanced development trends, as territorial disparities among the Member States and regions within the Member States increase owing to the effects of the economic crisis (Third ESPON Synthesis Report). In the result, the Territorial Agenda of the European Union 2020 emphasises that territorial cohesion is a common goal. The Green Paper on Territorial Cohesion identifies three main components of territorial cohesion: balanced and harmonious development, overcoming divisions and territorial inequalities and regions with specific geographical challenges (The Green Paper). The concept „territorial cohesion" in essence is a complex umbrella concept, which includes:

- flows and connectivity (networks, functional areas, services of general economic interest);
- spatial nodes (settlement structure, clusters, economies of agglomeration);
- maritime and terrestrial macro-geographic space use and organisation (e.g. ecosystems);
- territorial assets e.g. institutional set-up, cultural landscape, identity and integrity etc. (How to strengthen...)

At an informal meeting of the ministers responsible for spatial planning and territorial development (19 May 2011), it was requested to regularly organise the Territorial Agenda Annual Conference initiated by the Belgian Presidency and the ESPON Programme and other institutions such as the

European Environment Agency were asked to contribute to this aim. (Territorial Agenda of the European Union 2020)

The understanding and assessment of territorial cohesion as a phenomenon and a process is a focus for scientists as well. First, it involves explaining the nature of this phenomenon (Camagni R, Faludi A., Molle W., Medeiros Ed.; ESPON INTERCO). Yet, presently there is no single definition of territorial cohesion available either in the institutional documents of the European Union or in research studies by scientists (Madeiros Ed. 2014a:7), which fortunately does not hinder analyses of current processes in the European Union as a whole and in individual parts of the EU territory and EU Member States (Adams N., Cotella G., Nunes R. (eds), 2011; Bronisz U., Ophem J. van, Heijman W.; Canagni R., Capello R.; Medeiros E., 2014b). In Latvia too a number of research studies have been performed (Cingule-Vinogradova S., Jermolajeva E; Kruzmetra M., Rivza B.; Lonska J.; Bulderberga Z.), which focused on analyses and assessments of the regions forming the country. **The aim of the research** is to formulate the territorial cohesion system of the Baltic States as a region of the European Union. To achieve the aim, two tasks are set: 1) to single out and describe the similar variants of territorial cohesion and their interrelation; 2) to justify the importance of internal disparities across the regions in Latvia to identify the challenges to be tackled for reducing these disparities. **The method of the research**: to examine the research problem, the following information sources were used: the EU legislation and the reports of international and EU institutions; various sources of scientific publications, research papers. The description of the real situation is based on EU, FAO and Latvian statistical data, which were grouped, compared and analysed, and conclusions were drawn. The conception of territorial cohesion that suggests reducing disparities between the levels of development of the various regions based on smart, sustainable and inclusive growth as the main objective was selected as the **research methodology**. Cohesion can be seen as a principle of action (something must be done), ethics (a set of values, such as economic, social and territorial equity) and an integrative concept (multi-dimensional approach) (ESPON INTERCO...).

RESULTS AND DISCUSSIONS

The Baltic States form a certain region on the eastern coast of the Baltic Sea owing to their territorial integrity and similar historical background. An ESPON publication, in which European territorial structures are depicted on a map, convincingly shows that the Baltic States shape a region with many similar and, at the same time, distinctive features (ESPON ATLAS ...).

I VARIANTS OF TERRITORIAL COHESION IN THE BALTIC REGION

If viewed from regional positions, cohesion policies in the Baltics have to be multidimensional, as they have to involve two external comparisons:

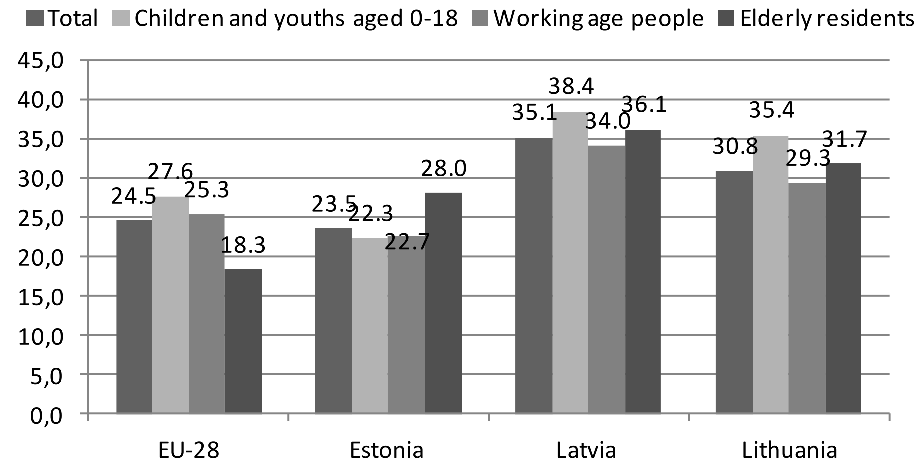
- a perspective on the situation in the EU on the whole from the state's positions, which might be a comparison with both the average indicators of the entire EU and the maximum level in some Member State;
- since the Baltics or the Baltic region is comprised of three states, each of them may be compared with the other two states forming this region.

These two perspectives on cohesion are well illustrated by the figures presented in the following table, with a challenge to bring the situation in the Baltic States closer to at least the average indicators in the EU Member States as well as to the average among the three Baltic States.

The situations in the three Baltic States are often compared, usually stressing the superiority of Estonia regarding its indicators and searching for an answer to Latvia's lagging behind. GDP per capita, for example, in 2013 (EU 28 = 100, PPS) was 73 in Estonia, 73 in Lithuania and only 64 in Latvia (EUROSTAT). For this reason, indicators of agriculture as an industry of national economy are divided into two groups in the FAO database: Estonia is included in the group of high income countries, while Latvia and Lithuania are in the group of low and middle income countries (The State of Food.., 2014:161). Unfortunately, labour productivities in agriculture are quite different and rise at different rates, which is a challenge to cohesion at least for Latvia.

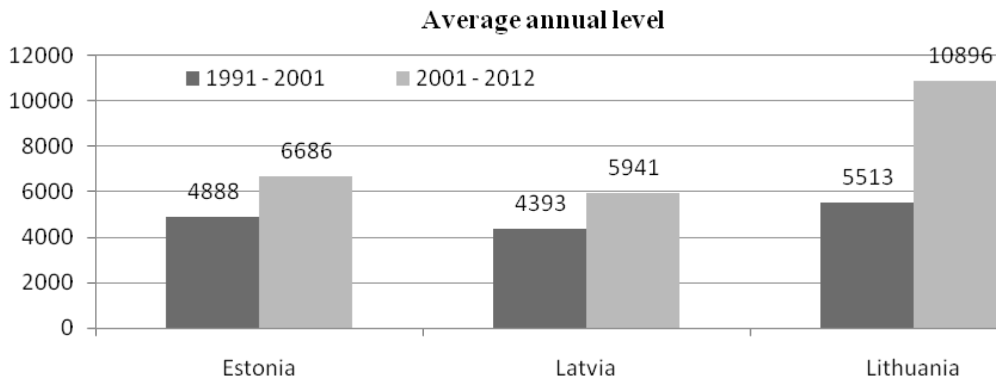
Lithuania is the leader in the Baltic region both in terms of value of agricultural production per agricultural worker and in terms of increase rate of this value.

A similar situation emerges if comparing the net migration for 2013 per 1000 capita: 2.0 in Estonia, 5.7 in Lithuania and 7.1 in Latvia (Demography 2017:90).



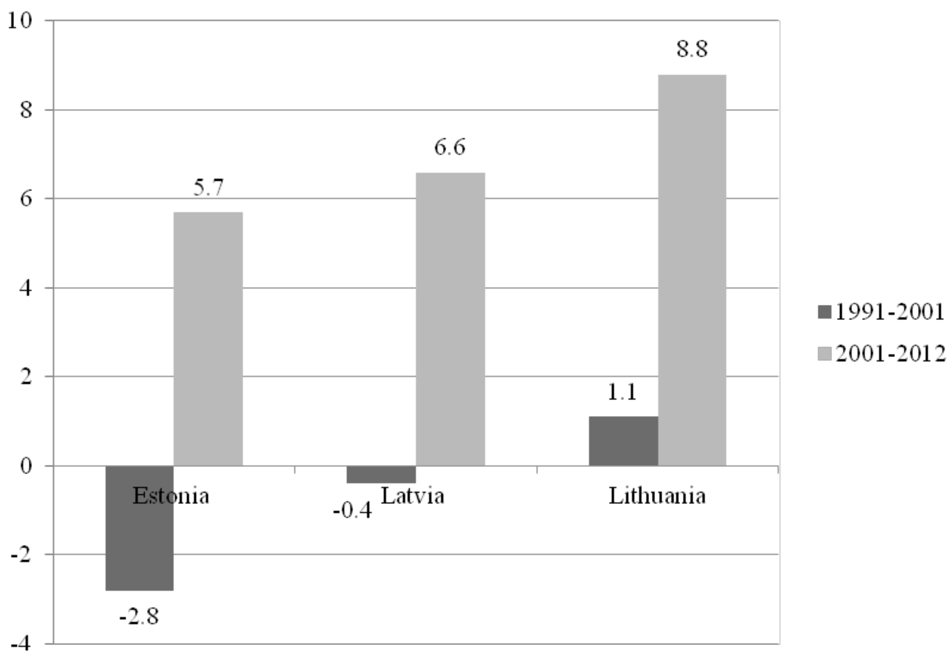
Source: Statistical Yearbook of Latvia 2014:480

Figure 1. **Proportion of the population subject to the risks of poverty and social exclusion in 2013**



Source: authors' construction based on The State of..,2014:161

Figure 2. **Agricultural labour productivity (value of agricultural production/agricultural worker)**



Source: authors' construction based on The State of.., 2014:161

Figure 3. **Change in agricultural labour productivity in the years of independence**

In the Baltic region, a challenge has been the adoption of the single currency of the European Union, as Estonia introduced the euro in 2011, while Latvia did it in 2014 and Lithuania in 2015. In the period of five years, a single currency system emerged in the Baltic region, which paved the way for making economic and social contacts in an easier way.

The identification and tackling of such problems is the result of communication of the leading EU structures, on the one hand, and the leading institutions of each Baltic State, on the other. Analyses of situations and cohesion processes are performed on behalf of the leading EU institutions by such scientific research structures as ESPON (European Spatial Planning Observation Network), EPRC (European Policies Research Centre), the Austrian Centre of Regional Science, etc.

In addition to these two external comparisons, the EU's cohesion policies envisage two cohesion variants to be implemented within a Member State, as the EU can address territorial development challenges and helps unleash territorial potential not only at national and transnational but also at local, regional levels (Territorial Agenda...). The first one of them involves comparing indicators of the regions forming the Member State, identifying disparities and elaborating a plan of activities to reduce the disparities, which comprises a significant part of regional development programmes.

Table 1

Internal disparities in Latvia at the level of regions

Region	Demographic burden per 1000 capita	GDP per capita in 2011, EUR	Household disposable income per equivalent consumer in 2012, EUR
Riga	591	15573	571.79
Pieriga	597	8082	516.95
Vidzeme	606	6555	392.24
Kurzeme	625	8762	462.34
Zemgale	585	6606	418.11
Latgale	600	5602	353.24

Sources: Demography 2014:39; CSB of the Republic of Latvia, 2014.

Interesting research studies on cohesion problems in Poland, Scandinavia, Lithuania and Latvia too have been carried out with regard to this aspect. A research study conducted on the basis of data for Poland convincingly show the results of economic development in its regions, which are affected by intellectual and social capital disparities in these territories (Bronisz U., Ophem J. van, Heijman W., 2014). Territorial cohesion is fostered by cross-border cooperation in Scandinavia (Medeiros E., 2014b). In Lithuania, the development of social infrastructure was identified and justified as an important territorial cohesion factor (Atkociuniene V., 2014). Urban-rural cooperation as a driver of regional cohesion (Bulderberga Z., 2014) as well as individual income disparities across the regions and the factors that presented significant effects of territorial affiliation on the disparities were researched in Latvia (Lavrinoviča I., 2014).

Finally, internal disparities across the regions forming the country were detailed, which turned out to be sufficiently significant and had to be reduced for the purpose of sustainable development. Only a few figures are given to confirm it.

Table 2

Internal disparities in Latvia within the regions

Within 20 municipalities of Zemgale region	Indicator	
	maximum	minimum
Individual merchants and companies per 1000 capita	31.6	10.2
Average enterprise registered capital, EUR	35921.93	817.56
Population change, %, in the period 2009-2014	– 9.7%	+ 2.5%

Source: authors' calculations based on SRDA RDIM model data

With this territorial cohesion perspective becoming popular in the EU's official documents and in research studies (ESPON INTERCO..), in Latvia, too, research interest in the internal disparities across the regions forming the country and in the opportunities for reducing these disparities increases (EKOSOC-LV, 2014).

II A CHALLENGE OF REDUCING THE INTERNAL DISPARITIES ACROSS THE REGIONS FORMING THE COUNTRY

According to the 2013 territorial development index (TDI), a situation has emerged in Latvia that convincingly indicates the necessity for implementing a cohesion policy in the country, as very marked disparities across the regions and even more pronounced disparities within the regions actually exist.

Table 3

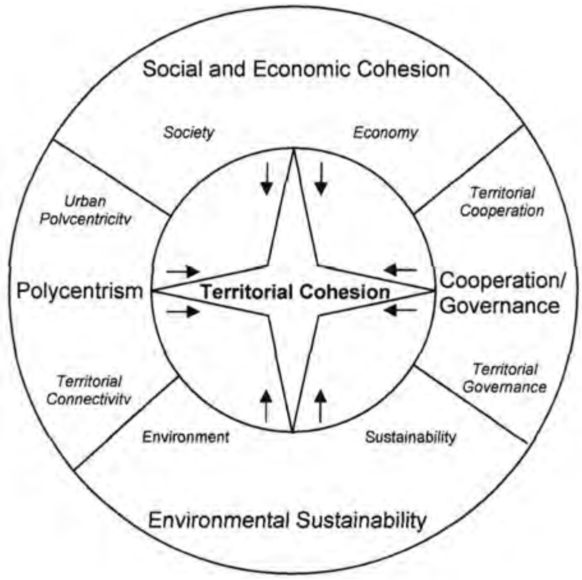
Internal disparities in Latvia

Territorial development index (TDI)	Vidzeme region	Kurzeme region	Zemgale region	Latgale region	Riga region
Maximum	+ 0.536	+ 0.543	+ 0.502	- 0.625	+ 2.731
Number of municipalities with a TDI above the average – 40	5 municipalities	6 municipalities	4 municipalities	0 municipalities	25 municipalities
Average in the country = 0.0					
Number of municipalities with a TDI below the average – 70	20 municipalities	12 municipalities	16 municipalities	19 municipalities	3 municipalities
Minimum	– 0.949	– 0.836	– 0.804	– 1.530	– 0.766
Difference between Maximum and minimum	= 1.483	= 1.379	= 1.306	= 0.905	= 3.497

Source: authors' calculations based on SRDA RDIM model data

The set of figures presented in Table 3 leads us to several conclusions. First, at regional level, two groups may be distinguished: three regions (Vidzeme, Kurzeme and Zemgale) having relatively similar characteristics and two regions (Latgale and Riga) that, first, have very distinctive characteristics if compared with each other and, second, their characteristics are diametrically opposite. Riga region and Latgale region may be characterised as two antipoles; the first one is the maximum gainer, whereas the second one is the maximum loser. This is the only case where performance results are significantly affected by the territorial location, as Riga region consists of a large part of the Riga agglomeration, while Latgale region lies beyond the boundary of the agglomeration. Second, the figures presented convincingly reflect the size of disparities in each of the regions – the minimum is observed in Latgale region, whereas the maximum is reported in Riga region.

Since any situation is influenced by both exogenous and endogenous factors of both objective and subjective nature, examining cohesion challenges is urgent. The territorial development index presently includes only statistical quantitative indicators that determine the situation but do not answer the question why some municipality develops, the situation improves and the outflow of residents declines there, whereas another municipality with the same or even greater amount of resources presents almost no development or even its development declines. It indicates that a greater number of criteria have to be employed to assess the development of a territory in order to identify the effects of activities that contribute to cohesion. A model with measurable territorial cohesion indicators that, besides usual economic and social indicators, also incorporates territorial connectivity, territorial cooperation and, finally, territorial governance as an organising and driving force, which was proposed by E.Medeiros, can serve as an optimal methodological option for this purpose. In addition, such indicators have to reflect two different periods of time in order to determine the vector of change (Medeiros E., 2014a).



Source: Medeiros E. ,2014a:13

Figure 4. **The star of the Territorial Cohesion**

In 2014, a national research programme entitled EKOSOC-LV was initiated in Latvia. Its purpose was to establish a basis of knowledge on sustainable development processes in the country and society and to elaborate a theoretical framework for a sustainable development strategy and policy; the programme also included the task to examine Latvia's rural and regional development processes and opportunities in the context of knowledge economy (EKOSOC-LV, 2014). The development of Latvia's rural areas and regions is closely associated with all the variants of territorial cohesion. For this reason, examining local territorial cohesion challenges also involves identifying the factors contributing to balanced spatial development of rural areas and regions.

CONCLUSION

Territorial cohesion has become one of the most important priorities in the European Union's development programme until 2050 and is also included among the CAP priorities for the period 2014-2020, which confirms the close interaction of rural development and agricultural production as a national industry in order to maintain rural areas as a sustainable space for life and activity.

Territorial cohesion as a phenomenon and a process simultaneously involves four pathways for reducing disparities, starting with the highest level – the perspective concerning the European Union as a system as a whole – and ending with reducing local territorial disparities within any EU Member State. Focusing on the territorial cohesion pathways, which to a greater or lesser extent take place simultaneously, make one think of the interaction of causes and consequences of the pathways and of their consideration in designing cohesion policies, as all the simultaneously functioning pathways form an integrated system, with the exogenous and endogenous factors affecting processes coexisting.

From the perspective of Latvia, important challenges are caused by the necessity to reduce territorial disparities across the country's regions and, equally important, within the regions. Reducing regional disparities has been the focus for scientists and has been researched in many aspects; unfortunately, internal disparities of the regions, their causes and forms and especially the ways of tackling them have been the focus neither for scientists nor for politicians, even though the disparities were significant. Since the municipalities forming the regions, in accordance with the ESPON methodology, are predominantly rural or intermediate territories, reducing the internal disparities of the regions, at the same time, contributes to wellbeing in rural areas as a space for life and work.

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TWENTY YEARS AFTER – WELFARE EFFECTS OF THE APPLICATION OF THE CAP IN AUSTRIA, FINLAND AND SWEDEN

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Abstract. *Twenty years ago, Austria, Finland, and Sweden joined the EU. The application of the Common Agricultural Policy (CAP) caused major repercussions on the agricultural sectors of the entering countries. This article analyses the effects of accession to the EU on the agricultural markets in Austria, Finland and Sweden in a simple supply and demand framework, which is kept strictly identical across all three countries. The quantitative results of the study are derived by using standard partial equilibrium comparative static analysis in the Marshallian economic surplus framework. Using this method, the welfare effects are calculated for eight major cereal and livestock commodities produced in Austria, Finland, and Sweden by comparing the evolution of the markets with and without entry into the EU. The results of the analysis suggest that consumers have gained from accession and producers, on the other hand, have incurred welfare losses from changing market conditions, which however have been eased by rising budgetary support.*

Key words: *EU, CAP, Austria, Finland, Sweden, welfare analysis.*

INTRODUCTION

At January 1, 1995 the internal market of the European Union (EU) was extended to three new member states: Austria, Finland and Sweden. Accession to the EU, and the application of the Common Agricultural Policy (CAP) changed the operational environment of the agri-food sector within each of the three countries. Agricultural policies were altered substantially implying a new price structure, production quotas and direct income payments to tillable land and animal units. Obstacles to trade were abolished with the rest of the EU, and EU regulations started to be applied in the trade with the third countries immediately on accession.

The question of the benefits and costs of the accession into the EU and compliance with the CAP was hotly debated in all three countries before the accession. However, not many estimates of the actual benefits and costs from the application of the CAP appear to exist to-date (Kola et al. 2000, Niemi 2005, Niemi et al. 2005). This paper attempts to provide both qualitative and quantitative estimates of the effects of application of the CAP on the agricultural sectors of Austria, Finland and Sweden. The twenty-year period from 1995 to 2014 should provide sufficient information for an appraisal of the consequences of the accession on agri-food sectors of the three countries.

The accession has eventually affected production, consumption and trade of agricultural products in three countries under examination and thereby influenced market balance also in the rest of the EU. The effects, thus, concern various groups within the countries, e.g. consumers, producers, the government, etc., as well as EU countries as a whole. We shall here concentrate on the inter-group transfers within a country, and neglect the possible inter-country income transfers. The accession has only very limited impacts on the agricultural markets in the whole EU, as the three countries are minor players in production and trade in relation to the EU and its major export producers.

Initially, the agricultural policies in Austria, Finland, and Sweden before and after entry are briefly discussed in the paper. Then the impacts of accession on agricultural sectors are evaluated and compared (section 2). Section 3 concentrates on quantitative analysis on welfare effects of integration. Static calculations are used to illustrate how adopting EU price levels have affected producer and consumer surpluses. In addition, the budgetary transfers between the three countries and the EU are presented in the context of the CAP. The final section summarizes the findings.

EXPERIENCES OF AUSTRIA, FINLAND AND SWEDEN UNDER THE CAP

In principle, agricultural policies of the three countries (Austria, Finland and Sweden) were in many ways similar to the one of the EU before the entry. Decent incomes for the agricultural population, stabilising markets and availability of supplies at reasonable prices were common objectives of agricultural policy in these countries and in the EU.

The policy instruments used were to a large extent also similar: price support, quotas, intervention arrangements on the internal market and a system of border protection together with export support for surplus production, as well as direct income aids.

The level of support measured by Producer Subsidy Equivalents (PSE) in agriculture was, nevertheless, higher than in the EU in all three countries at the time of the accession. Finland had the highest PSE, while the support levels in Austria and Sweden were closer to the EU (table 1). The desire to become part of the EU led to some changes in direction of the agricultural policy of the entering countries already before the accession. However, border protection remained relatively high until the end of 1994 (with the exception of Sweden).

In the membership negotiations, the EU effectively achieved its objective of immediate alignment of producer prices. As CAP prices were considerably lower than producer prices in Austria and Finland, in particular, it was agreed that “degressive national aids to farmers should be authorized where support levels differ significantly”. For Austria and Finland it was important to reach a long-term support package that would guarantee the profitability of agriculture, although the producer prices dropped considerably when prices were adjusted to the EU level. Finland pushed for Less Favoured Area (LFA) status for all of its agricultural area. In Austria about 70% of the agricultural area is included in the LFA support (Niemi et al. 2005).

In addition, Austria received the opportunity to provide extra national aid (Grundbetrag) to small farms for a period of ten years, where existing LFA allowances are insufficient, and where these farms already received aid in 1993. For Finland and Sweden an important borderline is the 62nd parallel, to the north of which and in adjacent areas to the south permanent, so-called nordic agricultural national support can be paid. This national nordic support is paid on the basis of the hectares of agricultural land or heads of animal. The support may not lead to an increase in production or in the level of overall support observed during a pre-accession reference period determined by the Commission (Niemi et al. 2005).

The elimination of border protection with the rest of the EU reduced barriers to trade as well as trade related transaction costs. This reduced domestic retail prices as well as producer prices and increased imports of agricultural products. The retail prices of food decreased only by about 0.5% in Austria and 1% in Sweden, but 11% in Finland immediately upon accession. Lower retail prices have in turn stimulated growth in consumption. In the food chain the position of retail sector has strengthened relative to the domestic raw material production and food industry within each of the three countries. The retail sector has been able to take advantage of the competition between the domestic food companies and between the domestic companies and the foreign ones.

The manner, in which adjustment in the agrifood sector (primary production as well as the processing industry) has proceeded, has been dependent on agri-industrial structures and the relative competitiveness among different types of firms, commodities and countries. The accession has affected agricultural production differently in different regions, also depending on the formulation of compensatory policies. The adjustment process has therefore by no means been uniform. Furthermore, the three countries exhibit significant regional variations within national boundaries. The following subsections looks in detail at the effects of price and subsidy changes on agricultural production, trade and processing industries within each of the three countries.

QUANTITATIVE EXAMINATION OF THE EFFECTS OF COMPLIANCE WITH THE CAP

The quantitative results of this study are derived by using standard partial equilibrium comparative static analysis in the Marshallian economic surplus framework. This method based on welfare economics is well known, for both its usefulness and limitations. Corden (1957), Deaton and Muellbaur (1980), Just et al. (1982) and Gardner (1987) provide useful discussions of the concept of producer and consumer surplus. Using this method the welfare effects of entry into the EU and compliance with the CAP are evaluated for eight major cereals and livestock commodities produced and imported in Austria, Finland and Sweden. These eight products account for almost 80% of the output of basic agricultural production at market price in the three countries under examination.

Economic surplus measures (i.e. producer and consumer surplus) are calculated by comparing the evolution of the agricultural market with and without entry into the EU. As with most policy changes, the response of the individuals impacted by integration depends on the time perspective. In this analysis we focus on the medium term, which is defined as the period that at least one factor is fixed. The basic formulae for calculation are represented by equations (1) through (8):

1) estimated domestic production without entry into the EU

$$Q_1 = Q_2 + n_s\,[(r_1 - r_2)/\,r_1]\,Q_2$$

2) estimated domestic consumption without entry into the EU

$$C_1 = C_2 + n_d\,[(p_1 - p_2)/\,p_1]\,C_2$$

3) net social benefit in production as a result of accession

$$\mathrm{NCB_p} = [0.5\,(Q_2 - Q_1)] * (r_2 - r_1)$$

4) net social benefit in consumption as a result of accession

$$\mathrm{NCB_c} = [0.5\,(C_2 - C_1)] * (p_1 - p_2)$$

5) welfare gain of producers as a result of accession

$$\mathrm{PS_d} = [Q_1 - 0.5\,(Q_2 - Q_1)] * (r_2 - r_1)$$

6) welfare gain of consumers as a result of accession

$$\mathrm{CS_d} = [C_1 + 0.5\,(C_2 - C_1)] * (p_1 - p_2)$$

7) change in taxpayers' expenditure as a result of accession

$$\mathrm{TX_d} = Q_1\,(r_1 - p_1) - Q_2\,\,(r_2 - p_2) + \mathrm{S_2} - \mathrm{TX_2}$$

8) net social benefit in society as a result of accession

$$\mathrm{NSB_d} = \mathrm{NCB_p} + \mathrm{NCB_c} + \mathrm{TX_d}$$

where r_1 is the per-unit return faced by domestic producers under a non-entry scenario; r_2 is the per-unit return in the entry scenario; p_1 is the market price faced by domestic consumers under a non-entry scenario; p_2 is the market price; Q_1 is the simulated production quantity under a non-entry scenario, Q_2 is the actual quantity of production; C_1 is the simulated consumption under a non-entry scenario, C_2 is the actual quantity of consumption, n_s is own-price elasticity of supply, n_d is own-price elasticity of demand, $\mathrm{S_2}$ represents the sum of direct subsidies received from the European Guidance and Guarantee Fund (EAGG), and $\mathrm{TX_2}$ represents country's payment to the EAGG.

Substituting non-entry prices into the supply and demand equations allows us to estimate a level of consumption and production in the no-entry alternative. From this, the net social losses and changes in consumer and producer surpluses can be calculated. Information required for the analysis are entry and non-entry prices and support production and consumption of agricultural products and own-price supply and demand elasticity estimates by commodity for Austria, Finland, and Sweden.

Table 1

Estimated change in agricultural production as a result of accession in Austria, Finland and Sweden, % of 1994 production

	Austria		Finland		Sweden	
Commodity	Low	High	Low	High	Low	High
Wheat	-2.2	-3.3	-2.4	-6.4	-2.4	-3.6
Barley	-1.0	-1.9	-0.5	-2.4	-1.5	-3.8
Oats	0.1	0.3	-0.6	-2.8	-1.6	-4.0
Beef	-1.1	-2.6	-1.9	-14.9	-3.1	-11.4
Pork	-1.6	-10.2	0.0	-7.3	-8.9	-12.4
Poultry	-1.9	-5.4	-1.4	-5.5	-1.2	-2.5
Eggs	0.5	1.4	-1.8	-4.5	9.4	16.8
Milk	-2.1	-9.7	-0.9	-6.1	-0.8	-2.1

The effects of entry into the EU on production and consumption volumes are summarised in tables 1 and 2, from which a number of points can be made. In the non-entry scenario, the net returns received by agricultural producers are higher than the corresponding returns under entry. Therefore, when production and supply are positively related to producers' net returns, agricultural production is estimated to be lower in the entry scenario. On the other hand, as a result of lower food prices there is an increase in domestic consumption with the entry into the EU.

The effects on trade are merely a combination of the effects on production and consumption, since stocks are assumed to be constant. The entry has caused an increment in the import of all agricultural products analysed.

Table 2

Estimated change in consumption of agricultural products as a result of accession in Austria, Finland and Sweden, % of 1994 consumption

	Austria		Finland		Sweden	
Commodity	Low	High	Low	High	Low	High
Wheat	6.0	24.6	10.8	29.3	1.2	4.5
Barley	5.5	18.4	6.4	21.9	1.6	4.9
Oats	5.8	19.8	6.7	23.3	1.7	5.3
Beef	1.5	11.5	5.4	21.7	3.3	12.7
Pork	3.3	5.0	9.3	34.1	3.4	10.8
Poultry	3.9	12.8	4.3	19.9	0.8	3.0
Eggs	-0.8	-1.3	6.1	16.8	-7.9	-14.7
Milk	1.3	6.7	0.2	1.7	0.2	1.5

The most sizeable effects of entry are the welfare transfers between producers and consumers. Producers both in Austria and Finland have incurred large welfare losses in commodity production, which are to be contrasted with the increase in budgetary support. In Austria, producers' welfare losses due to the CAP range from EUR 701 million (the low elasticity case) to EUR 726 million (the high elasticity case) per year. Producers in Finland have incurred welfare losses from a low EUR 573 million to a high EUR 600 million per year. In Sweden, producers' welfare losses range from EUR 376 million to EUR 389 million per year (table 3).

In Austria, the magnitude of the losses has been most pronounced for the dairy and pork producers. Dairy producers' welfare loss ranged from EUR 265 to EUR 277 million. Pork producers have lost from EUR 238 to EUR 250 million. In Finland and Sweden the losses are largest for the beef and pork producers. Finnish beef producers' welfare loss ranged from EUR 213 to EUR 229 million. Swedish pork producers have lost between EUR 161-164 million.

Table 3

Welfare gains of producers as a result of accession in Austria, Finland and Sweden, EUR million per year

	Austria		**Finland**		**Sweden**	
Commodity	Low	High	Low	High	Low	High
Wheat	-77	-78	-26	-27	-34	-34
Barley	-17	-17	-26	-26	-29	-30
Oats	0	0	-25	-25	-21	-21
Beef	-50	-50	-213	-229	-128	-134
Pork	-238	-250	-139	-144	-161	-164
Poultry	-58	-59	-13	-13	-16	-16
Eggs	5	5	-14	-14	57	56
Milk	-265	-277	-118	-121	-45	-45
Total	-701	-726	-573	-600	-376	-389

On the hand, consumers have gained an estimated EUR 2,087-2,197 per year in the three countries. In Austria, consumers have gained about EUR 898-931 million per year for the total of eight major commodities analysed. In Finland and Sweden, consumers have gained about EUR 815-875 million and

EUR 374-391 million, respectively. Clearly, these gains are important to consumers, even though the magnitude of these benefits is small relative to market sales (table 4).

Apart from transfers between producers and consumers, there are budgetary transfers, which must also be taken into account when documenting welfare changes in the whole society. Countries' contributions to the EAGG is not known, since payments are made to the EU budget as a whole and not to each special fund separately.

However, if we make the usual assumption that the proportion of a member states' contribution that goes to EAGG is equal to the share of EAGG in the total budget, we find that Austria and Finland have been net receivers from the EAGG in 2003. Sweden, on the other hand, has been a significant net payer.

Therefore, the net budgetary benefits from the application of the CAP in 2003 amount EUR 548 million in Austria, and EUR 180 million in Finland. In Sweden, the EU-membership has lead to an increased burden for taxpayers, of at least EUR 500 million annually.

Sweden has one of the highest net per capita contributions to the EU and money received within the CAP are not at all of the same size. It is also worth to notice that governmental payments in 1994, our reference year, were relatively high since that was a year of "compensation payments" for the Swedish deregulation agricultural reform. Compared to a post-reform year in Sweden the differences therefore ought to be even higher.

Table 4

Welfare gains of consumers as a result of accession in Austria, Finland and Sweden, EUR million per year

	Austria		**Finland**		**Sweden**	
Commodity	Low	High	Low	High	Low	High
Wheat	132	123	107	101	26	26
Barley	92	87	107	99	29	28
Oats	16	15	86	80	14	14
Beef	89	85	176	165	174	167
Pork	205	203	245	223	159	154
Poultry	72	69	67	63	20	19
Eggs	-7	-7	56	53	-75	-79
Milk	332	324	31	31	45	45
Total	931	898	875	815	391	374

CONCLUSIONS

The objective of this study was to compare the welfare derived from the existing EU situation with that derived from a hypothetical non-entry situation for agricultural markets in Austria, Finland and Sweden. The analysis is based on a simple Marshallian supply and demand framework and differentiates eight commodities. The benefit or cost of integration is the extent to which welfare under current situation deviates from welfare under the non-entry scenario. Whether all these benefits and costs could have been avoided by not entering the EU is doubtful, as the outcome of the Uruguay Round Agreement on Agriculture would have hit the country similarly.

The quantitative results of the study indicate that the most sizeable effects of integration are the welfare transfers between consumers and producers. According to the study, consumers in all the three countries have gained, in total, between EUR 2,087-2,197 for the eight major commodities analysed. Producers, on the other hand, have incurred large welfare losses in commodity production, ranging from EUR 1,650 to EUR 1,715 million. These losses are to be contrasted with the increase in budgetary support, however.

The EU-membership reduced average agricultural prices in all three countries. Consumer gained more than produces lost from this. An increased market competition in processing has probably also contributed to welfare gains from the EU-integration. The generous acceptance from the EU-commission in relation to environmental programs and national exceptions in the form of additional national support compensated farmers. When evaluating the aggregated welfare effect, taxpayers situation therefore become essential. Sweden seems to lose because of a large net transfer to the EU, while Austria and Finland seems to be net gainers from the implementation of the CAP.

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APPLICATION OF RURAL DEVELOPMENT POLICY IN SEE COUNTRIES: BEHAVIORAL ECONOMICS APPROACH

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***Abstract**. The rural development and its specific policy is a relatively new concept for transition countries aspiring to join EU. The South-Eastern Europe countries, Macedonia, Serbia and Bosnia and Herzegovina are transition countries on the way to EU, with substantial rural resources. Therefore, rural development policy is crucial for their sustainable development and quality of life of rural people. In the same time, the impact and success of such policy depends strongly on farmers' attitude, capability, understanding and motivation to use available funds. The aim of this paper is to determine and understand the factors behind the behavior of farm managers when applying for rural development funds. The analytical framework is based on the Theory of planned behavior, where the individual intention to perform a given behavior determines the performance and is shaped by the attitude, social pressure and the perceived behavioral control. This theory is widely applied in various scientific fields; but so far such an approach has not been used in understanding farmers' population and use of rural development programs. The survey took place in November-December 2014, in face-to-face interviews covering 895 farm households in Macedonia, Serbia and Bosnia and Herzegovina. The principal component analysis of the statements related to the farmers' opinions on rural development policies yielded into three logical factor sets related to the farmer's attitude, approval to apply and the perceived abilities of the farmer to use the available measures. The identified factors and their relations could be used for designing a more suitable approach to encourage and guide the farmers to maximize their use of available funds for rural development. This knowledge could serve as a basis for recommendations for policy makers when designing policies and informative materials, and for extension agents and advisors to improve their approach when addressing the rural issues.*

***Key words**: Rural development policies, farmer behavior, SEE countries, Theory of planned behavior.*

INTRODUCTION

The countries from South-Eastern Europe (SEE) have a common goal to join the European Union. Macedonia and Serbia, as candidate countries, and Bosnia and Herzegovina, as potential candidate, committed to reforms and necessary adjustments for EU accession. Agriculture is among the most important sectors of the national economies in terms of value added, as well as important contributions to the economic and social stability. The accession process involves primarily improvement of the agro-food chains competitiveness, but also more broadly "adopting a quite different model of agricultural policy more demanding in its conceptual, administrative and financial aspect" [1].

Currently, half of the population in the SEE countries lives in rural areas (or specifically, 42% in Macedonia, 52% in Bosnia and Herzegovina and 40% in Serbia). There is an ongoing trend of abandoning rural areas and looking for employment opportunities in the urban centers within the countries and abroad. These migrations and considerable population ageing have negative impact in economic, social, spatial and ecological terms. Extensive agriculture is still the essential driver of the rural economy and source of employment and subsistence in the rural areas of all three countries; there are very little other opportunities, thus part-time and seasonal jobs are very often the only source of income out of agriculture. Economic services and social infrastructure are underdeveloped, which affects the competitiveness and the social fabric of rural areas. Furthermore, there is poor diversification of economic activities and the expansion of entrepreneurship is hindered by factors such as underdeveloped infrastructure, lack of skilled labor, limited access to markets and to finance, lack of investment support and low entrepreneurial potential.

The specific agro-climatological conditions are different among or even within the countries, but also the structural characteristics of the agricultural sectors are respectively distinctive. This implies different importance of market support measures and direct payments between the countries and also customized approach to national rural policy. The current agricultural policy in all three countries is partly harmonized with the EU Common Agricultural Policy principles, but budgetary support is still very low (from about 47 Euro/ha in Bosnia and Herzegovina, to 148 Euro/ha in Macedonia). In addition, the funds for structural and rural development measures are at much lower level, amounting to around 20 Euro/ha or comparatively at 10% of the EU average. Investment support measures intended for improving the competitiveness of agriculture dominate among the funds for rural development, while the rest is accounted for by rural economy measures (most present in Serbia) and very little by agri-environmental support [2]. Due to the low level of budgetary support, the current rural development policy and other regional policies cannot address most issues hampering rural development, though additional support is becoming available through the EU pre-accession instrument for rural development (IPARD). Major difficulty in accessing rural development related policies and in particular IPARD instruments appears to be the inadequate administration and institution capacity at national and local levels, on one side, and the low capacity of potential beneficiaries *i.e.* rural population, on the other side. With decreasing focus on production and productivity, rural economic and land use policy analysis and appraisal should essentially be informed by models that reflect the factors which influence farmers' decisions [3]. In this regard, the need to support the socio-economic development in rural areas by better understanding the behavior of rural population, in particular their attitudes and motives, becomes apparent. Therefore, the aim of this paper is two-fold: (i) to determine and understand the factors behind the behavior of rural population when applying for rural development funds, and (ii) to provide recommendations for policy makers, extension agents and advisors to improve their approach when addressing the farmers.

MATERIALS AND METHODS

Theoretical framework

Farmers' actions result from complex processes influenced by socio-economic and psychological variables [4]. The conceptual model of this study is based on the Theory of Planned Behavior (TPB) developed by Ajzen [5], where the individual intention to perform a given behavior determines the performance. The individual intention is influenced by the direction and intensity of the attitude towards the behavior, the subjective norm and the degree of the perceived behavioral control. The term attitude entails the degree of favorable or unfavorable perception of certain issue; the subjective norm is actually the social pressure of performing some action; and the perceived behavioral control refers to the knowledge and previous experience that might limit/restrict or push/emphasize a specific behavior. The more positive the attitude, subjective norm and perceived behavioral control, the stronger is the intention to engage in a behavior, and the greater the likelihood of the performance of the behavior. Ajzen [5] further emphasizes that personal behavioral control together with the behavioral intention can directly predict behavioral realization. This theory is widely applied in various scientific fields; it also had been used in relation to farmer behavior and agricultural policy studies (see [3],[6]), farm management aspects [7],[4]; but so far such an approach has not been used in understanding farmers' population and use of rural development programs, especially in a EU approximation driven policy context.

Data collection and processing

To meet the specific requirements for this study and fulfill the set goal, a survey took place in November-December 2014, in face-to-face interviews covering 900 farm households in Macedonia (MK), Serbia (RS) and Bosnia and Herzegovina (BA). The specifically structured questionnaire for this opinion survey was organized in three major parts: rural development policies; cooperation and networks; and farm household management; producing a database with 147 variables. The current analysis was carried out on 25 statements reflecting the opinion on rural development policies (a combination of statements on farmer's attitudes, subjective norms and perceived behavioral control) and the stated intentions to participate in these policies, measured through a 5-point Likert scale (whereas 1 denoted strong disagreement and 5 strong agreement with the statements). The data were processed using the SPSS software package for multivariate techniques.

Following the descriptive statistics of the country samples on the farmer defining parameters, and non-parametric tests on the statements to determine the differences between the countries (Kruskal-Wallis test and Mann-Whitney as *post hoc* procedure), an exploratory factor analysis was performed.

Principle components analysis was used as method to identify and compute composite scores for the factors underlying the farmer's behavior towards RDP. The minimum amount of required observations for factor analysis was satisfied, with a final aggregate sample of 895 observations (using pairwise deletion), hence providing around 12 observations per variable on country level or 36 observations per variable on aggregate level. Standard criteria for examining the factorability and adequacy were used. The Kaiser-Meyer-Olkin measure of sampling adequacy was meritorious with value over .8 and the Bartlett's test of sphericity was significant (p=.000) in all country samples, both individually or aggregated. The items with communalities under .5 were retained. The number of factors was determined using parallel analysis, using a random set of eigenvalues and the solution was further confirmed by the visual scree test and the Kaiser's eigenvalue-greater-than-one rule. In order to get interpretable factors, orthogonal Varimax rotation was applied.

RESULTS AND DISCUSSION

The profile of the samples by country and on aggregate level is shown in Table 1. The average age of farmers is over 45, with a high variation within the sample. Most of the farmers are with low level of education, but with long experience in farming. It is interesting to note that the farmers in Macedonia are almost solely relying on agriculture, while in Bosnia and Herzegovina and most notably in Serbia, many farmers have additional household income from other sources. It its highly likely that the farmers will stay in agriculture, though most do not know who will take over their farm and continue the farming activity.

The number of farms that applied and received rural development support and the average amount received per famer is different among the country samples, hence reflecting the different level and available rural development measures in the countries. Namely, in Serbia 8% of the farmers in the sample applied for RDP support with 84% success rate and received in average 2,510 Euros; in Bosnia and Herzegovina 37% applied, 55% of them were successful and received in average 1,250 Euros; and in Macedonia, although comparatively highest support of 5,600 Euros per farmer was received, only 25% applied with 65% success rate.

Table 1

Profile of samples on country and aggregate level, mean values

	MK	**RS**	**BA**	**All**
Sample characteristics	299	300	296	895
Age (years)	46.5	52.8	48.9	49.4
Number of years worked in farming	25.6	27.9	18.1	23.9
Number of years in education	10.1	10.8	11.6	10.8
Share of production sold on market (%)	96.3	59.3	72.2	75.9
Share of income coming from farming (%)	90.4	58.2	66.2	71.6
Likeliness to stay in farming (1-def.not; 5-def.yes)	4.6	4.4	4.5	4.5
Identified successor (1-def.not; 5-def.yes)	2.9	3.2	3.0	3.0
RDP Support				
Farmers that applied for RDP support (%)	25.1	8.3	36.5	23.2
Farmers that received RDP support (%)	16.4	7.0	19.9	14.4
Received RDP support per farmer (Euro)	5,625	2,512	1,253	/

Most farmers in all countries were generally either positive or neutral to use RDP for their own household in short and mid-term perspective, while their intention to participate in RDP common projects for the rural area was less enthusiastic and mostly neutral.

The Kruskal-Wallis test on the RDP opinion statements showed significant differences among the countries ($p<.05$). The follow-up Mann-Whitney test displayed that the Macedonian sample statistically differs from the other two country samples for most statements. This can be explained by the fact that Macedonia has a specific RD policy with EU harmonized institutional organization (programming and implementation structure). There is an evidence of similar farmer's attitude to RDP in Serbia and Bosnia and Herzegovina, while there are some statistically significant differences in the subjective norms and perceived behavioral control between them.

The PCA provided a snapshot of the opinion of the surveyed farmers regarding the rural development policies, resulting into four components in the case of Serbia and Bosnia and Herzegovina and five components in the case of Macedonia and in the aggregate sample (Table 2). The total variance explained by the solution ranges from 65% in RS to 71% in MK. The retained factors were synthesized into three logical sets, verifying the applied TBP conceptual framework: farmer's attitudes, subjective norms and perceived behavioral control.

Table 2

Rotated component matrix of scores, at country and aggregate level

	MK	RS	BA	All
Farmer's attitudes				
17. RDP leads to improvement of the infrastructure in rural areas.	.787	.785	.777	.765
18. RDP leads to protection of environment, local breeds and varieties.	.829	.838	.819	.816
19. RDP leads to higher implementation of EU standards.	.751	.801	.751	.801
20. RDP leads to higher networking of rural population.	.785	.821	.818	.793
21. RDP leads to stronger development of rural tourism.	.755	.743	.801	.675
22. RDP supports the survival of small family farms.	.816	.806	.800	.680
23. RDP increases the income of the farms and rural households.	.790	.824	.681	.669
1. In general, I think it is good that the state has a RDP.	.730			
26. The principle of co-finance in RDP projects is good motivator for farmers.	.770			
Subjective norms				
7. The decision whether to apply for RDP is totally up to me.	.783		.740	.569
8. My family approves the application for the RDP.		.782	.829	.709
9. Other people I respect approve the application for the RDP.	.714	.849	.768	.811
10. Many people I know pursues me to apply for the RDP call.	.708	.698		.753
Farmer's perceived behavioral control				
2. The RDP application (procedure and documents) is easy.	.867	.640	.885	.878
3. The preparation of the RDP application is not expensive.	.853		.879	.840
4. The information regarding the RD program is easy to get.	.653	.808	.789	.764
5. I have enough information to independently prepare the application (procedure and documents).	.727	.904	.827	.838
6. My knowledge and experience is enough to independently prepare the application (procedure and documents).	.720	.768	.835	.855
14. I have enough own means to co-finance an RDP investment.	.811	.637	.571	.570
15. I am able to get bank credit to co-finance an RDP investment.	.683	.781	.649	.800
27. I can get credit easily.	.627	.744		.751
Total variance explained	**.71147**	**.65421**	**.70306**	**.68754**

Note: The derived components by countries are demarked with grey lines.

Since the idea of RDP is to induce long-term development based on the capacity building of beneficiaries, rather than just transfer of funds [8], a deeper insight into the driving factors of the farm manager's behavior should ensure sustainability of the developmental path. The farmers expressed their general attitude about the benefits of RPD, in terms of personal gains and overall for the rural areas. Over 90% of farmers in all countries thought that it is good to have a RDP. Most farmers (strongly) recognize the RDP as support for survival of family farms and improvement of farm income. The agreement with the benefits of RDP (stronger development of rural areas, improvement of infrastructure, protection of environment, closer networking, and implementation of EU standards) was rather moderate or strong with the famers in Serbia and Bosnia and Herzegovina, while the Macedonian farmers had mostly neutral response to these issues.

The support and approval from family and other people towards the application for the RDP is very important to the farmers in all country samples. In this set of subjective norms, it is interesting to note that in Serbia and Bosnia and Herzegovina it is mostly the farm holder that makes the decision whether to apply to RDP, while in Macedonia this decision can often be also shared. The recognition of the importance of social approval to farmers can be used as a supplementary promotional strategy contributing to the RDP success. Such strategy can be built on additional social network analysis for identification of “agent of change” or a “village leader” who is widely respected and able to spread “good word” about program in order to motivate and support the others to apply to RDP.

The aspects of personal ability and control over information, knowledge and experience to independently prepare the RDP application were generally perceived as a barrier. Since the RDP application procedure in Macedonia is more demanding [also evidenced in [9]), this limitation is measured with a stronger intensity. In this context, policy measures need to become accessible and applicable by providing continuous simplification of the application procedures, intensified extension support (one solution could be setting up “one-stop-shop” for documentation issuing), free and easy access to beneficiary database and development of mechanisms to prevent/report corruption, which was also recognized as an issue. As it is case in other transitional countries [10], our research findings suggest that barriers to RDP are multiple and interacting. Farmers are still uncertain of how well they are managing the application process; this stresses the farmer’s need for support in the application process and facilitated access to relevant information. In addition, the farmer’s self-confidence should be continuously built up, by well defined trainings and education through “lessons learned campaigns”. Last but not least, co-financing is an important requirement for participation in RDP, hence strengthening the access to credit and improving the options for co-financing could without doubt additionally encourage the use of RDP.

CONCLUSIONS

The rural development and its specific policy is a relatively new concept in the SEE countries. Although gaining importance, its implementation is far behind the market support measures and direct payment schemes. The success of RDP depends strongly on the attitude, capability, understanding and motivation of farm managers.

Applying the TPB approach, we demonstrated that the farmers have positive attitude and expectations regarding RDP based on beliefs that it will lead to improvement in infrastructure, quality of environment and foster implementation of EU standards, in individual terms and in general for the rural areas. The RDP strategies have to build on these identified positive attitudes. The approval from the family and other people in the farmer’s environment is especially important and as such should be taken into account when designing, in particular, promotional strategies. Major barrier was found in the farmer’s personal ability and control over information, knowledge and experience to independently prepare the RDP application, which emphasizes the need for adequate support.

Therefore, in order to increase the success of RDP, it is necessary not only to define proper policy measures, but also it is highly recommended to find out supplementary policy promotional strategies. Given the current attitudes and behavior of the farmers, we suggest several strategies to improve the level of RD measure implementation: identification of “agent of change”, a “village leader” that is widely respected and will promote RDP, motivating the others to apply; simplification of the application procedures, with corresponding extension support; easier access to comprehensible information; easier access to credit and better options for co-financing; development of mechanisms to prevent/report corruption.

This knowledge could serve as a basis for recommendations for policy makers and the extension community to improve their approach when addressing the farmers, thus increase the effective utilization of the rural development policy instruments.

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ASSESSING INTERVENTIONS SUPPORTING SUSTAINABLE DEVELOPMENT IN RURAL AREAS – A DIALOGICAL APPROACH

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Abstract: *Based on the Community Capitals framework, developed by Professors Jan and Cornelia Flora of the Iowa State University, the paper puts forward a dialogical method for assessing, mainly public, interventions supporting sustainable development in rural areas. The framework proposed by Flora & Flora identifies seven types of capital, collective resources that serve as basis for sustainable development. These capitals include for instance natural, social, human, cultural and economical capital. The paper expands the understanding of natural capital by introducing ecosystem services to the framework, hereby bridging the concepts of a bio based economy and sustainable development. By basing sustainable development of rural areas on ecosystem services the notion of the city as resourceful and rural areas as scarce is challenged. The paper presents the adapted framework.*

Via contextualization and operationalization of the different kinds of capitals in a Scandinavian setting indicators are established. These enable initial assessment of a community aimed at tailoring (public) interventions supporting sustainable development based on ecosystem services. The method has been successfully tested in a few cases in Denmark and Sweden within the Interreg IV A KASK project "Rural Regions". Further adaptation and development is to take place in upcoming research and projects. In the paper it is demonstrated how the community capitals framework is used as a structure in participatory dialogical processes, raising awareness within the community itself as well as guiding public bodies supporting sustainable development in rural areas.

The method is based on initial surveying of available data followed by a semi structured dialogue with representatives from the community resulting in a graphical representation of the assessment. Based on the assessment it is possible to discern whether an intervention ("investment") in the community is meaningful, and how it should be designed to strengthen the community's capacity for sustainable development.

Key words: *ecosystem services, community capital, sustainable development of rural areas, dialogical approach.*

THEORETICAL FRAMEWORK

In an overview by the Swedish Research Council Formas [1], they conclude that research aimed at sustainable development in rural areas is a "thin and fragmented genre" and that there is a need for a more "sustained building of capacity for research into cultural, social, economical and ecological conditions". Despite this lack of consistent knowledge and capacity public interventions are made both on EU, national and regional levels. The European Commission states that "similarly, policy that sets out to stimulate rural development must be weighed up against its success at achieving it . . . there is considerable work to be done to define the appropriate indicators" [2], and Thomson argue that ""rural development" means – or should mean – structural and institutional changes in the rural parts of the wider economy. This definition would include changes in all components, including production, consumption and trade, as well as economic processes such as new forms of marketing and policy delivery." [3] To analyse and successfully intervene for sustainable rural development we need a more systemic and integrative approach.

In order to identify key factor contributing to a community's capacity to work together for a common good Jan and Cornelia Flora [4] have introduced the concept "social entrepreneurial infrastructure". They argue that where social capital is abundant, it is more meaningful to intervene. Strengthening the social will increase a community´s capacity, thus creating opportunities for more effective interventions by public sector. According to Flora & Flora three basic "structures" make up social capital:

- Diverse symbolic structure
- Resource mobilization capability
- Diversity of networks

These structures are operationalized [5], to gain an understanding of how they are means to attain a sustainable development.

Diverse symbolic structure is understood as a capacity to disagree while retaining mutual respect. There is an acceptance for different opinions, among others by separating problems and solutions. It is permissible to point out a problem, and to survey different solutions in cooperation. During the conversation the item at hand is separated from the messenger, enabling participation without the risk of being personally attacked. A diverse symbolic structure is also characterized by a broad, inclusive definition of the community and by permeable boarders against the surrounding world. Diverse symbolic structure is surveyed by examining cultural root systems, such as religious affiliation. Public and other support for sustainable development is also of interest. Local schools, good relationships with regional authorities, a sense of regional belonging and for instance the existence of local newspapers are also deemed interesting. Through studies of the local history an understanding of how conflict is managed is also established (managing by doing nothing is included). Public festivals and more are also used as indicators, etc.

Resource mobilization capability, where the term resource is used in a wide sense, is assessed from different factors: how equal is access to different resources such as education and leisure activities? Large, communal (i.e. public), investments is seen as contributing to equal access. Private investments also contribute and are assessed by surveying in what amount local banks and businesses finance local initiatives. A general expectation of people to contribute to the common good, and high status and joy associated with these contributions is another part.

Where there are networks among relatively homogenous but different groups it is an indicator for so called diversity networks (young and old, women and men, different ethnic groups and maybe the most difficult: newcomers and long time dwellers etc.). Both horizontal and vertical networks contribute to a sustainable development; horizontal networks by connecting different communities, vertical by connecting a community with a regional or federal level for support.

Flora & Flora take a narrative and qualitative approach when assessing the social capital. Interviews and conversations are paramount. Statistics and the local paper are other important sources. From this basic understanding Flora & Flora have developed the model on social capital further and established a framework of Community Capitals, a seven perspective approach. [6]

Capital in this framework is viewed as collective resources, not just individual property. The types of capital are shown in a particular order, with *natural capital*, the natural environment, being the first and the basis for all the others. In our approach we have expanded this to ecosystems based capital.

1. *Ecosystems based capital* includes the quality and quantity of water and soil, air quality, biodiversity, and the landscape, as well as all functions that the natural environment enable (pollination, water cleaning, erosion control, etc.). It can be viewed as a set of resources to be extracted or as a source of life that needs to be tended and cared for, depending on a group's cultural capital.
2. *Cultural capital* determines how communities and groups within communities see the world, how they connect the seen and the unseen, what they take for granted and what they think is possible to change. Cultural capital is often highly determined by and determines natural capital.
3. *Human capital* represents the skills, abilities, and knowledge that each human being possesses in a community.
4. *Social capital* consists of interactions among people and groups for mutual support. It involves trust, shared norms, reciprocity, and working together. Social capital has two dimensions: bridging and bonding. Bridging social capital is the linking of local groups or institutions to resources and external partners with similar goals, while bonding social capital is the strengthening of internal organization and the capacity to take collective action based on the common backgrounds and experiences of the individuals or groups involved
5. *Political capital* refers to the codification of community's norms and values into standards that are supported by rules and regulations, which are enforced equally.
6. *Financial capital* is the financial instruments, including but not limited to money, that can be easily traded and monetized.

7. *Built capital* refers to technology, infrastructure, tools, and machinery. While an individual can accumulate tools and machinery, collective goods such as roads, water systems, school buildings, and community centres are generally best generated by a community working together.

TAILORING INTERVENTIONS

Assessing different resources and tailoring interventions based on local resources is a way of supporting a sustainable development in a community, and conducting appropriate follow up based on indicators. Indirectly, it also challenge the notion of the city as resourceful and rural areas as scarce, mainly by basing sustainable development of rural areas on a broader view on existing capitals and ecosystem services.
In our research the Community Capital approach is used to contextualize and operationalize the different kinds of capitals in a Scandinavian setting. Furthermore, indicators are established as a dialogical tool. Together, these enable initial assessment of a community aimed at tailoring (public) interventions supporting sustainable development based on local resources and ecosystem services. The method has been successfully tested in a few cases in Denmark and Sweden within the Interreg IV A KASK project "Rural Regions". Further adaptation and development is to take place in upcoming research and projects.
In the paper it is demonstrated how the community capitals framework can be used as a structure in participatory dialogical processes, raising awareness within the community itself as well as guiding public bodies supporting sustainable development of rural areas.
Table 1 exemplify possible interventions and what the expected outcomes are (based on the work of Flora & Flora and adapted to a Scandinavian setting).

Table 1

Examples of interventions and expected outcomes

Intervention	Expected outcome
Investments in ecosystems based capital Actions aimed at achieving environmental objectives and increasing capacity and value of ecosystem services.	**Changes in ecosystems based capital** Healthy eco systems creating value for the community. Increased revenue based on eco system services.
Investments in cultural capital Using traditional knowledge and values to drive a sustainable development.	**Changes in cultural capital** Cultural awareness, identified possibilities and limitations. Strengthened dialogue and meeting places.
Investments human capital Use or add knowledge and skills to drive a sustainable development. Empower people to increase governance.	**Changes in human capital** Enabling participation and empowering people to contribute. Capacity for responsibility, initiative and innovation increases.
Investments in social capital Facilitate cooperation between different parties. Strengthen participation. Cooperate with parties outside the community. Strive toward diversity.	**Changes in social capital** Increased communication and cooperation internally and externally, strengthening of networks and trust. New groups contributing to sustainable development. New leaders emerging.
Investments in political capital Strengthen capacity and facilitate relationships with relevant bodies.	**Changes in political capital** New arenas for co-creation between public sector and the community. Moving from government to governance.
Investments in financial capital Direct resources, both external and local.	**Changes in financial capital** Local economic development, strengthening both balance sheet and revenue.
Investments in built capital Spatial planning supporting sustainable development.	**Changes in built capital** Increased gross regional net product. Appropriate infrastructure.

The mix of capital looks different from one rural area to another. Each area has a given potential, which are met in higher or lower degree. It is within such a framework a constructive dialogue among stakeholders are triggered: What do we have to build a sustainable future from? Where are our strengths and our weaknesses? How can we measure progress?

PROPOSED PROCESS FOR DIALOGUE AND ASSESSMENT

The assessment of an area or a community is done by stakeholders and carried out in a series of seminars. The starting point for the discussion is based on an initial survey as well as the experiences that the participants bring into the seminar. The participants receive the results of the survey beforehand to enable them to prepare for the seminar.

The initial survey is developed from available statistics. Every capital is described, discussed and assessed at the seminar. To simplify and to help participant to keep the whole picture in mind, the assessment is based on a scale from one to ten (table 2), the quality and reliability of the assessments are also estimated (table 3) and the result finally represented in a combined graph (figure 1). The ambition is to both clarify and simplify, but without reducing existing complexity. By doing this we enable stakeholders to learn together about existing potentials for sustained rural development. The integrative approach help the participants to keep the different capital forms in mind at the same time, and in dialogues identify new ways forward. From the perspective of public authorities one main benefit is that they can identify critical thresholds for interventions, supporting capacity building activities where needed or funding initiatives where the local community has a potential for sustained action.

Table 2

Assessment of capital, using a scale from 1 to 10

1.	Very scarce –almost no resources
3.	Sufficient resources – the resources suffice to conserving a status quo
7.	Resources enough to develop – there are resources enough to create sustainable development
10.	Abundant resources – the resources are basically limitless

Table 3

Assessment of reliability in the used data used for analysis

1.	The material has significant shortcomings
2.	The material has deficiencies
3.	The material is reliable
4.	The material is very reliable

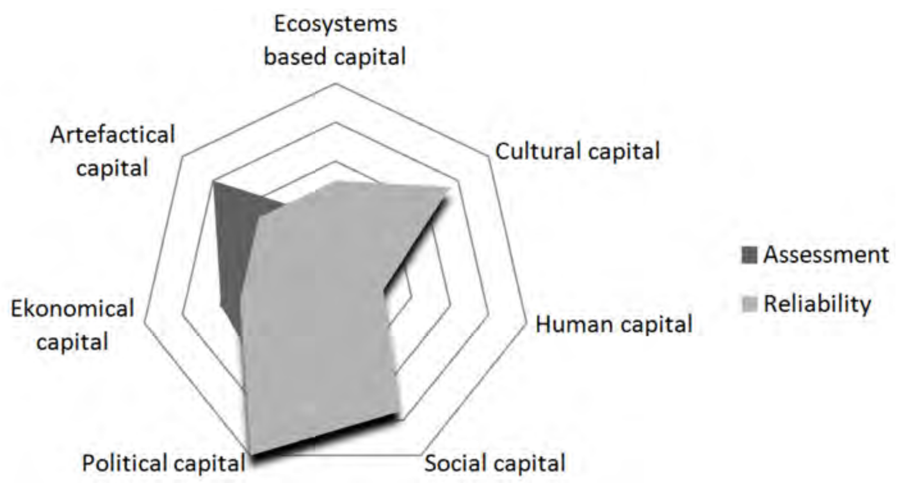

Figure 1. **The results of the assessment and the reliability of the material are presented in a combined graph**

The graph developed by participants has a pedagogical function. The graphical representation used to conduct the community capital assessment balances and contrasts social and ecological factors. In a broader sense it can also be used to inform resource planners about the environmental implications of human needs and the impact of land-use decisions on human populations. One example is when developing artefactical capital by destroying ecosystem based capital, leading simultaneously to increased economical capital and to decreased cultural capital. Such dynamic and complex processes can be illustrated by the graph, supporting systemic learning processes.

CONCLUSIONS

So far we have tested the Community Capital framework in a Nordic pilot-project. Regardless rural context it seems to be applicable, and it enable an integrative and participatory dialogue among stakeholders. We argue that by assessing Community Capitals in a community:

- Awareness within the community is created.
- Interventions can be tailored to strengthen capacity within the community and increase effectiveness of public interventions.
- A multi-perspective understanding of situation and potential in rural areas is established and maintained.

The Community Capital framework addresses some of the needs described by Formas [1] and others [7]. We are now planning to test this approach in different real-life settings where development processes have been initiated, from physical planning and landscape strategies to the development bio-energy and local services.

ACKNOWLEDGEMENTS

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EMPLOYMENT AND LABOUR MARKET DEVELOPMENT IN NORDIC AND BALTIC STATES

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Abstract. *Employment is the main factor influencing welfare of the population. The scientific problem of this research is to identify the interrelation between employment development and labour market development and to foresee measures for increase of employment on a regional level. Seeking to solve this problem, it was made an analysis of the concepts of employment and labour market as well as EU unemployment policies. Empirical research was conducted on the base of Eurostat data on employment using method of multivariate statistical analysis. The results of the research, provided in this paper, show the changes employment and share of self employment in the period 2000-2013 in NUTS2 level regions of Nordic and Baltic countries EU member states. The recommendations provided in this paper offer ways to increase of employment in rural areas in regions investigated.*

Key words: *Employment, entrepreneurship, labour market, regional development, EU policies.*

INTRODUCTION

An employment is the main factor influencing welfare of the population. It is very closely related to economic development of the countries and particular regions. In face with a vast concentration of manufacturing and service provision very often working places are migrating from territories with low density of population to bigger towns or cities with higher concentration of population. But these tendencies very often are in conflict with the interests of inhabitants in the regions, who are wishing to find the job in living or neighbouring area. The scientific problem of this research it was formulated in following way – to identify the interrelation between employment development and labour market development and to foresee measures for retention of existing and (or) creation of new working places (jobs) in regions with rural areas. Seeking to solve this problem, it was made an analysis of the concepts of employment and labour market and EU unemployment policies. Empirical research was concentrated on changes in employment and labour market development and identification of critical points if changes and measures targeting an increase of employment in the regions were investigated.

The aim of research presented in this paper is to evaluate the dynamics of employment and labour market development in NUTS2 level regions of Nordic and Baltic countries, EU member states and to recommend the measures to increase of employment in these regions.

The tasks of research:

1) To analyse the concepts of employment and labour market and describe the interaction between these concepts.
2) To make an analysis of EU unemployment policies.
3) To create designs of methodology for assessment of interaction between employment and labour market.
4) To make an analysis and evaluation of the results of empirical research and to provide recommendations to increase employment in Nordic and Baltic countries EU member states.

MATERIALS AND METHODS

The theoretical research deals with concepts of employment and labour market, factors, influencing levels of employment, critical points of economic development as well as EU policies in the area of employment.

An empirical research was carried out to identify the trends of employment, entrepreneurship and labour market development in Nordic and Baltic countries, EU member states and to prepare recommendations targeting to increase of employment on regional (rural) level.

For preparation of the theoretical part of this paper there were used an analysis of scientific literature and strategic documents, logical analysis, comparison, summarising and others research methods. For processing of empirical data there were used the method of multivariate statistical analysis and others.

Data for estimations are taken from the Eurostat database (extracted on January 5th in 2015). Data of both indicators – employment level and share of employees – for the NUTS2 regions in 2012 and 2013 are estimated. Additionally, data on employment level are estimated for Denmark NUTS2 regions in the period of 2000-2006 and for some NUTS2 regions in Finland (namely, Helsinki-Uusimaa, Etelä-Suomi and Itä- ja Pohjois-Suomi) in the period of 2000-2004. All the estimations are based on previous (or following) time series of the particular region using moving averages of the annual changes of the indicators.

Labour market development is measured by the level of employment. Labour force development (entrepreneurship level) is measured by the share of employees in the total number of employed persons. The assumption less share of employees – better entrepreneurship level, it was used.

RESULTS AND DISCUSSION

Definitions of the basic concepts of the labour market are based on mainstream theories, completed by critical observations of authors challenging orthodox views. There are several definitions of the notion "labour". Labour is a human activity that provides the goods or services in an economy [1]. Labour is a specific human activity, being the physical and intellectual capacity of the labour force, determined by the stock of people's skills, knowledge and experience, used to obtain economic, cultural and social goods [2].

Labour market by Osoian [3] had to be defined as the economic space where the owners of capital, as buyers (labour demand), transact freely with the owners of the labour, as sellers (labour supply), and where equilibrium between supply and demand of labour is ensured through specific mechanisms (price of the labour force, the real wage, free competition between economic agents, negotiation and other mechanisms). However, the OECD "market" definition differentiates between two fundamental dimensions [4]: a) the product market, which groups together products (in our case, the product is labour); and b) the geographic market, which groups together geographic areas.

The neoclassical model assumes that labour markets are flexible and wages clear the market, the economy operates at full employment, where labour is paid its marginal product [5]. In reality, labour markets are imperfect, limited markets, jobs and workers are heterogeneous, employers and employees do not always follow the criteria of profit maximization, capital and labour are interchangeable, labour market information is costly and imperfect, labour market actors react with delay to the changes to the market, and there are several barriers (geographic, institutional and sociological) to labour mobility [6]. It also has been observed that markets and people do not necessarily behave in a rational manner, even if they have accurate and timely information [7].

Labour markets may be local, national or international in their scope and could consist of smaller, interacting labour markets for different qualifications, skills, and geographical locations. They depend on exchange of information between employers and job seekers about wage rates, conditions of employment, level of competition, and job location [8].

Employment is on a contract based relationship between two parties, one of which is being the employer and the other is being the employee. Employment is a result of the complex evolutionary process of interaction between economic activities and labour force. Background of employment in a regional level, especially in rural areas, is based on availability of local resources (endogenous assets) and usually is targeted to maximise the internal potential of the region [9].

The interaction of the labour force and economic activities through the labour and labour contract agreement could be regulated by the government. The government in this case has a broad meaning – it is understood as a set of legislative and executive institutions, administrators, controlling and monitoring governmental bodies and etc. But government links with labour force is indirect and gets through the spending of public money on education, health, and trainings of labour force [9].

Comparison of labour market development between different regions is complicated because of several critical reasons. The essential reason is that labour market is a socioeconomic category, while rural area is physical and demographic category. In other words, the geographical boundaries of the labour market and rural area do not match. It is always a case that labour market goes beyond the boundaries of rural, municipality, county or national territory. The analysis of the rural area as a socio-economic category is constrained not by the number and structure of job places or labour force, but also by the geographical area in which the jobs are taking place or a labour force is living [9]. Another reason follows from the first one. As labour market boundaries are larger than the administrative territory of the rural area, the labour market expands in the neighbouring areas [9].

In March 2000 the European Council set out a ten-year strategy with the overarching aim to make the Union "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" [10], which is known as the „Lisbon Strategy". The focus was shifted from the reduction of unemployment to regaining the conditions for full employment and concretised the aims: to raise the EU employment rate to 70%, to increase the share of employed women to more than 60% and of the labour force aged 55-64 to more than 55% by 2010 [10]. But implementation of this strategy met some challenges, the most significant of which it was economic slowdown in EU in 2003 and global economic recession in year 2008-2009.

As a result of economic slowdown unemployment has increased in a number of Member States in the year 2003. Due to this in the report "Jobs, Jobs, Jobs: Creating more employment in Europe", which was presented in 2003, it was stated that the increase of employment and productivity in Europe depends on four key requirements [11]:

1. Increasing adaptability of workers and enterprises.
2. Attracting more people to the labour market.
3. Investing more and more effectively in human capital.
4. Ensuring effective implementation of reforms through better governance.

Employment rates at the end of 2008 in the EU reached 65.5% on average, 58.3% for women and 44.7% for older workers and thereby bringing the EU closer to the Lisbon targets [12]. Unfortunately, these positive changes were stopped by the global economic recession of year 2008-2009. Due to this in the Joint Employment Report for year 2009 the EU Member States there were recommended actions with particular importance in the short and medium term [13]:

– Contractual arrangements: reduce segmentation, harmonise conditions for temporary and permanent contracts;
– Active labour market policies: prioritise job subsidies and equivalent measures leading to rapid integration of the unemployed persons into a job;
– Effective lifelong learning systems: focus on short-term skills upgrading, and enhance matching of the skills of the unemployed with the available jobs;
– Modernise social security systems: reduce high marginal effective tax rates on the low paid.

The Draft Joint Employment Report for 2013 [14] shows the decrease of GDP stopped much earlier then grows of unemployment. Between year 2008 and the second quarter of 2013 the unemployment rate in the EU-28 increased from 7.1% to 10.9%, but the growth of unemployment was stabilised [14].

According to Marelli and Signorelli [15] many "old" European countries partly thanks to labour market reforms have been able to create more jobs in the post recession decade, but Lisbon strategy must be completed in two ways: 1) by paying much more attention to the "better" jobs specification (not only by the increase of employee's welfare, but, also, by fostering their effort and motivation); and 2) by focusing more directly on productivity growth which, in several European countries, has been particularly lacking. Mentioned above authors also conclude, that after the recent global economic crisis, which had a deep impact on European labour markets, it is extremely important the future fiscal consolidation (necessary to offset the current increases in deficits and debts) should not be too detrimental to those public expenditures functional to economic growth and productivity dynamics, a long run prerequisite for achieving "more and better" employment [15].

According to Doran and Jordan it is advisable to consider that under the new economic geography theory and endogenous growth theory, it is desirable to produce agglomerations of economic activity as these allow for economies of scale and higher levels of living standards to be generated, what would not be possible if the agglomerations did not exist and provision of greater economic autonomy to regional levels may result in policies designed to attract large-scale employment from multinational corporations [16].

Employment as a concept is complex and dynamic. According to the model of the employment system labour and labour contract depends on supply of jobs and supply of labour force. Jobs places are "business" side of the employment system and supply of labour is "occupational" side of the employment system [9]. In rural areas most of institutional components have significant links with "business" and "occupational" sides of the employment system. The interaction of all these components brings results and effects which by itself are important for a viability and development of the employment system [9].

Important role in job creation in rural areas has entrepreneurship of rural inhabitants. Therefore, persons, occupied in rural areas are characterised not as high-growth entrepreneurs, but more as lifestyle entrepreneurs, who are in search of a (rural) lifestyle that enhances the quality of life in rural communities [17]. Policies aimed at strengthening the rural economy through side activities should focus primarily on the people involved in the side activities and less on the environment. Secondly, the policy question related to the spatial land use regime is addressed. Side activities are small-scale activities located and in most cases do not claim or seek to claim much space and additional land [18].

The results of empirical research are based on usage of data from Eurostat database are presented in figure 1. The employment in different NUTS2 level regions in Sweden in the year 2013 it was in range from 63% till 70%. During the period of 2000-2013 employment slightly decreased in Stockholm and in Östra Mellansverige and insignificantly increased in the rest regions of the Sweden. The share of self-employed persons during this period decreased in all NUTS2 level regions in Sweden, except Övre Norrland region, where this level increased by 1.1 percentage points till 3.7% in 2013. In general the fluctuation of employment and share of self-employment there was not significant in NUTS2 level regions in Sweden.

The NUTS2 level regions in Denmark in the period of investigation had lower employment than in Sweden and this level in different regions ranged from 55% till 61% in the year 2013. Since 2000 employment level decreased in all regions. The most radical decrease by almost 8.0 percentage points is seen in Sjælland and Syddanmark regions, compared to the modest decrease by 1.3 percentage points in Hovedstaden and by 2.6 percentage points in Nordjylland. Like in Sweden the share of self-employed persons in NUTS2 level regions in Denmark is low, ranging from 4.9% in Hovedstaden to 7.3% in Sjælland. A trend of decrease of the level of employment and increase of share of employees fits to all regions in Denmark.

The relatively different picture is in NUTS2 level regions in Finland. While Helsinki-Uusimaa region is very similar to the most NUTS2 level regions in Sweden, other regions in Finland have lower employment level and higher share of self-employed persons. The range of the level of employment between the different regions in Finland in the year 2013 was 50-62%. In all regions in Finland has seen a decline in employment level since 2000. The share of self-employed person in period of investigation has increased in Helsinki-Uusimaa and Etelä-Suomi regions and significantly decreased in Åland region 3.0 percentage points till 12.1% and in Itä- ja Pohjois-Suomi region by 2.4 percentage points till 14.2%. In summary the dynamic of changes in regions is different, but the gap between them is decreasing.

Most rapid changes in period of investigation are seen in Baltic countries. Lithuania had almost 20.0% of self-employed persons in 2000 and it was the highest level in countries investigated. But since 2004 the share of self-employed persons in Lithuania dropped by more than 10.0 percentage points indicating the attractiveness of being employed and getting the wage rather than participating in the market and depending on the incomes from sales. A similar trend is seen in Latvia and Estonia with a drop of self-employed persons by 3.6 and 0.3 percentage points accordingly. The range of the level of employment in Baltic countries in the year 2013 it was from 51% till 56%. Employment level has increased in all Baltic countries and now is similar to NUTS2 level regions in Finland, but still lagging behind the NUTS2 regions in Denmark and Sweden.

In the period 2000-2013 employment level has decreased in those NUTS2 regions in Nordic and Baltic countries, which had relatively high starting position, while employment level has increased in those regions which were lagging in 2000 and the gap between the regions decreased. The gap in the share of self-employed persons in the regions investigated also has decreased.

CONCLUSIONS

The concept of employment covers the self-employed persons and employees, who participates in the labour market. All factors, influencing development of all kinds of the economic activities, are of critical importance for increase in employment.

The EU policies on the employment of recent years there were turned on activation of labour market and reduction of its segmentation, on improvement of education, lifelong learning and retraining systems as well as on modernisation of social security system.

Analysis of the employment level in the Nordic and Baltic EU countries revealed that NUTS2 level regions in Sweden and Denmark have better employment rate, ranging from 55% to 70%, but these regions also have the highest share of employees in the total number of employed persons. The Baltic States and NUTS2 level regions in Finland have an employment level in the range of 50-56%, excluding Helsinki region with an employment level of 62%. The share of self-employed persons is higher in Finland and Baltic States, ranging from 8.4% to 14.2%, while this level in Denmark and Sweden is in the range of 4.2-6.9%.

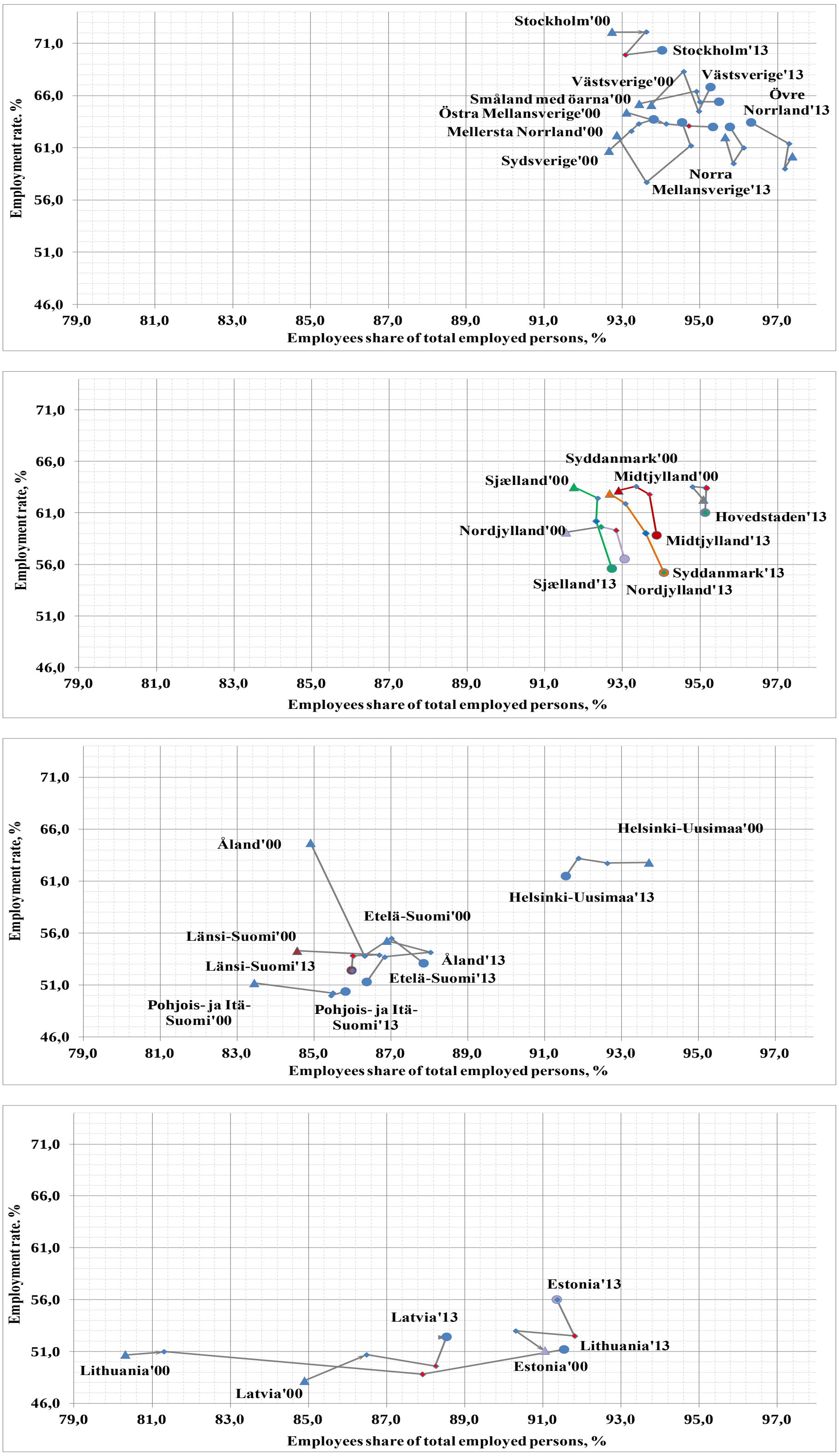

Figure 1. **The relation between employment development and labour market development in NUTS2 regions of Nordic and Baltic countries in 2000-2013**
(Each trajectory consist of four points for 2000, 2004, 2009 and 2013)

During the period of 2000-2013 NUTS2 level regions in Nordic and Baltic countries, EU member states has converged in terms of employment development and entrepreneurship level. The gap between the regions has decreased due to both faster changes in Baltic countries and different directions of employment level between the Nordic EU countries. The majority of the regions has a common trend towards the increase of the share of employees in total labour force and it means an increase of influence of labour market development and importance of the EU and local employment policy measures and other issues in the regions.

For increase of employment in NUTS2 level regions of analysed countries, advisable provide: a) promotion of entrepreneurship among rural, especially young inhabitants, b) monitoring on preservation of jobs created while implementing investment projects supported by local authorities, government or EU, c) promotion of competition amongst producers and services providers in rural areas by applying restrictions on capital and activity concentration in hand of few owners not only on state, but and on regional level.

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COMMON AGRICULTURAL POLICY (CAP) – FOR INCREASING EU COMPETITIVENESS IN GLOBAL MARKET

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Abstract. *EU is the largest economy in the world. It's the world's largest trading block and largest trader of manufactured goods and services. Despite the good position in global market the situation changes and EU must use all its strengths to keep its prime position in the global trade. The Common Agricultural Policy (CAP) is one of the oldest policies of the European Union and it has developed agricultural sector for more than 50 years. CAP 2007-2013 has been implemented and new CAP period 2014-2020 is already in force. These are more than 130 billion EUR per year that will be used for agricultural and rural development. How does the CAP 2014-2020 will be used to promote common EU market and common offer for global market? How agriculture and food production could increase EU competitiveness in global market? CAP has created economical strengths over past years but to improve and develop EU agriculture it must solve the weaknesses that include also social, political and technological improvements. CAP should be focused on developing common agriculture in Europe with increasing all Europe competitiveness in global markets.*

Key words*: agriculture, common agricultural policy, competitiveness, rural development, global trade.*

INTRODUCTION

The EU still is the largest economy in the world with its 500 million consumers. It's the world's largest trading block and largest trader of manufactured goods and services. Despite the good position in global market the situation changes and EU must use all its strengths to keep its prime position in the global trade.
Since 2005 to 2013 EU share in world trade on goods has decreased from 17,9% to 15%. EU and US as well losses their share in world market and developing countries like Russia, India, Brazil although slowly but steady increase its share in the world trade. Special mention if for China that has rapidly increased its share in world trade on goods from 8,5% to 13,7% in last 8 years [2] To strengthen EU economical influence and share in global market a lot of trade agreements have been made.
EU agriculture and food products have good reputation in world market. There are 12 million farms and 25 million people (5% of all EU inhabitants) involved in agricultural production in EU. To support development of EU agriculture there has always been Common agricultural policy (CAP) since 1962 and it's still important role for agriculture and food producing in Europe. Although CAP has promoted export volumes, statistical data shows that only 4,9% of EU-28 export and a small part – 5,9% of EU-28 import has been food and live animals, animal and vegetable oils, waxes and fats [2]. The issue is how to ensure sustainable development for agriculture and rural areas at the time when economical competitiveness in global market has became priority.
There were 12.2 million farms in the EU-28 in 2010, with the vast majority of these (96.9 %) classified as family farms. Across all of the farms in the EU-28, family farms provided 86.2% of the regular agricultural labour force and reared 71.1% of all livestock in 2010. [6]. There were a large number (5.7 million or almost half of all holdings) of very small farms (less than 2 hectares in size) that farmed a small proportion (2.5%) of the total land area used for farming in 2010 and, on the other, a small number (2.7% of all holdings) of very large farms (over 100 hectares) that farmed one-half (50.2%) of the farmland in the EU-28. [7] This is also reflected in the economic size of holdings: there were 5.5 million holdings (44.6 %) which had a standard output below EUR 2 000. Many of farms, smaller than 2 ha, are characterized as semi-subsistence farms – more than 50% of their output is self-consumed [5]. By developing small farms and through increasing a standard output up to and more than EUR 2000, the economical growth for EU would be significant.
Common agricultural policy (CAP) should be focused on developing common agriculture in Europe with increasing all Europe competitiveness in global markets. But instead of that, CAP has been used to increase

benefits and competitiveness for each of the member states instead of building common European market offer for global markets.
EC Agricultural commissioner and representatives of EC and EP point out that the European agriculture meets a lot of challenges but does the CAP 2014-2020 really meet them? Does common policy faces the challenges for each of its regions and creates a common EU region for stronger position in world market?

METHODS

To analyze potential of CAP 2014-2020 for increasing EU global competitiveness there were 30 interviews done with experts on agriculture and rural development from 27 Member states – Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden, United Kingdom.
The experts were asked to evaluate the CAP 2014-2020 and their national Rural Development Programmes (RDPs) 2014-2020 on behalf of developing agriculture and increasing competitiveness of EU agriculture and food products in global market. Experts as farmers themselves and as national representatives of farmers in member states were appropriate group to analyze CAP 2014-2020 as a tool for increasing EU competitiveness in global market.
Interviews were made on March 2014 – March 2015 when drafts of National RDPs 2014-2020 were developed and the first RDPs 2014-2020 were approved by European Commission.
Expert views were grouped in “strengths” and “weaknesses” for SWOT (strengths, weaknesses, opportunities, threats) analyses and evaluated by using PEST (political, economic, social, technological) analyses.

RESULTS AND DISCUSSION

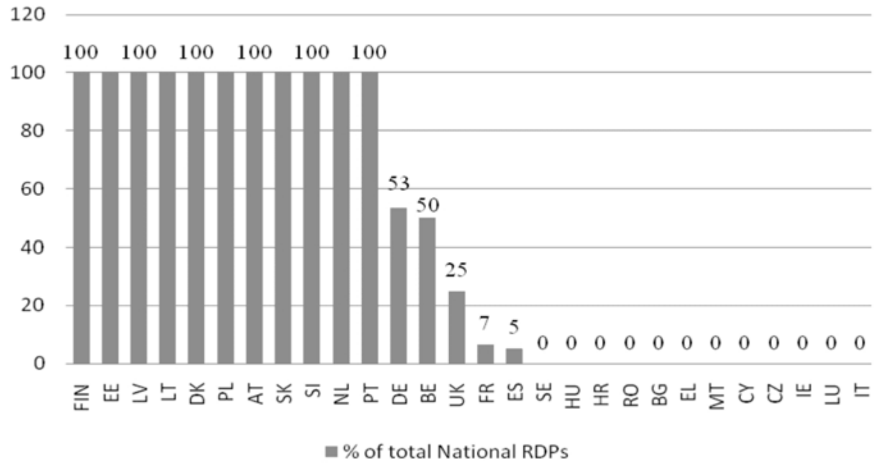
Common Agricultural policy 2007-2013 has been implemented and new CAP period 2014-2020 is already in force. That means that the new development agenda for rural areas for seven year period in EU is stated.
The new policy continues along this reform path, moving from product to producer support and now to a more land – based approach. This is in response to the challenges facing the sector, many of which are driven by factors that are external to agriculture. These have been identified as

- economic (including food security and globalization, a declining rate of productivity growth, price volatility, pressures on production costs due to high input prices and the deteriorating position of farmers in the food supply chain),
- environmental (relating to resource efficiency, soil and water quality and threats to habitats and biodiversity) and
- territorial (where rural areas are faced with demographic, economic and social developments including depopulation and relocation of businesses) [1].

The goal that CAP 2014-2020 strives for is sustainable development and CAP document contains a lot of references for ensuring sustainability in rural areas. CAP 2014-2020 focus on:

- knowledge transfer and innovation in agriculture, forestry and rural areas,
- farm viability,
- the competitiveness of all types of agriculture in all regions and promoting innovative farm technologies and the sustainable management of forests,
- the organisation of the food chain, including the processing and marketing of agricultural products,
- animal welfare,
- risk management in agriculture, restoring, preserving and enhancing ecosystems that are related to agriculture and forestry, to the promotion of resource efficiency and the shift towards a low carbon economy in the agricultural, food and forestry sectors,
- promoting social inclusion, poverty reduction in and the economic development of rural areas [8].

Although the new period for CAP has started on 2014 there are only 17 (out of 118) national RDPs approved by European Commission up to February 13, 2015. Only 11 EU Member states has approved RDPs for 2014-2020, 5 Member states has approved one or several RDPs per country but there are still 12 EU Member states were neither national neither any of regional RDPs are approved.



Source: created by the authors, based on information of European Commission [3],[4].

Figure 1. **Approved Rural Development Programmes** (data on 01.03.2015)

RDP 2014-2020 are approved for Finland, Estonia, Latvia, Lithuania, Denmark, Poland, Austria, Slovakia, Slovenia, Netherlands and Portugal. There are 8 (out of 15) RDPs approved for Germany, 1 (out of 2) – for Belgium, 1 (out of 4) – for United Kingdom, 2 (out of 30) – for France and 1 (out of 19) – for Spain. All other EU Member states don't have RDP approved by European Commission.

When the second year of period 2014-2020 has started only 35,95% of total EAFRD budget has been approved. That means that the largest part of EU farmers lives in suspense of new regulations and possibilities of their national or regional DRP. On CAP 2014-2020 there are essential changes like greening measures that are still unclear for farmers in all Member states as this is a new compulsory measure that farmers must take into account. Even more, the investment flow has almost stopped in large number of farms by waiting for RDP 2014-2020 activities and financial support.

The situation on CAP 2014-2020 implementation in this moment multiplies uncertainty and insecurity of farmers. Here will be two seasons spent (2014 and 2015) on waiting for final obligations and measures instead of putting clear and ambitious agricultural processing into action.

Expert interviews affirmed that there is a large uncertainty between farmers and even governments because of new CAP 2014-2020 and situation that for the largest part of EU Member states the CAP is not approved. Even on February 2015 DG AGRI was still working on implementation measures for greening when few of the Member states had already approved RDPs with only few options to change anything on approved RDP's document.

Experts indicated on several main strengths for EU agriculture and market but there were more weaknesses identified in this period when there are a lot of issues unsolved in agricultural policy.

As the main strength for EU agriculture was designated high quality and safety for EU food products and EU quality is a strong and positive brand in global markets. Experts point out that the large number of farms could become advantage of EU agriculture targeted support will be for increasing knowledge on agriculture and entrepreneurship for small farmers and productivity for small farms. The produced volume could increase rapidly and together with developing cooperatives that could become an economical growth for EU economy and export markets. Experts are consentaneous that common agricultural policy is important tool for EU agriculture and that has promoted development of larger farms that becomes more conversant and professional with innovative and modern technologies to produce more effective – faster, cheaper and larger volumes.

The weaknesses for EU agriculture has been mentioned high production costs that reduce competitiveness of EU farmers in global market. Different conditions as environmental protection, animal welfare, social requirements, special packaging rules, public information and others serves as a basis for qualitative and safe production but at the same time increases production costs mush higher as it is in other countries with lower social un economical conditions.

One more important case that weakens common EU position in global market is that Member States does not work and develop with common goal to ensure the best offer for global demand but they compete for better

conditions and internal market share between themselves within EU. Different history of national agriculture and food production as well as different experience as EU Member states has created unequal situation between EU Member states. CAP 2014-2020 doesn't solve this problem – inequality of agricultural sector between different countries will continue and perhaps even increase because the subsidies (Pillar I) still will be very unequal. The political situation in EU agriculture won't create a common agriculture and offer for global market because there is internal competitiveness between EU member states.
Farmers have realized that global market and changes in that has essential impact on their farming. Farmers are dependent on world market prices for raw materials, minerals, fuel as well as prices of grains, milk, meat and vegetables. It becomes hard to predict the prices for the products that has been grown or produced. Farmers are dependent and vulnerable in global market and common agricultural policy could help to manage uncertainty. As essential weakness for European agriculture was indicated uncertainty with CAP implementation and approval of RDPs 2014-2020.

Table 1

SWOT for European agriculture and market

Strengths	**Weaknesses**
– 12 million farms	– High production costs
– Small farms that ensure working places	– Low competitiveness in global markets
– Increases average size of the farm	– Inequality between member states
– Strong farmers' cooperatives	– Food import from third countries
– Financial support – subsidies for farmers	– Aging, lack of young farmers
– Latest equipment and technologies for more productive agriculture	– Influence of global market – unstable prices, international and transatlantic trade agreements
– High quality and safety for food products	– Lack of agricultural education for farmers
– Knowledge and experience	– Lack of entrepreneurship skills for farmers, especially for small scale farmers
– Large internal market for agricultural production	– Lack of agricultural work force, especially seasonal workers
– EU quality is brand in global market	– Decreases number of small farms. Farming becomes large scale farming.
	– Internal competitiveness between EU member states
	– Dependence on external markets - suppliers of raw materials
	– Complicated implementation of new CAP regulations
	– Uncertainty of new CAP implementation
	– Lack of long term CAP
Opportunities	**Threats**
– CAP as tool for building common agriculture in EU, common offer for global market	– Climate changes
– To develop cooperation and cooperatives for producing best demanded products in global market	– International and transatlantic trade agreements where development and competitiveness of internal agriculture is not the priority for EU
– To increase common competitiveness of EU agriculture in global market	– Internal competitiveness to have larger share on EU internal market
– Long term development policy (20-30 years) for agriculture and rural development in EU	– Lack of investments
– Investments to increase knowledge and experience for famers on agriculture and business	– Instability of markets and policy
– Significant support for young farmers	– Lack of workforce

Source: created by the authors, based on the interviews of 30 field experts from Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden, United Kingdom.

If evaluate strengths and weaknesses by using PEST analyses its shows that the largest part (almost all) of strengths are economical but from weaknesses it is not so clearly. There are political, economical, social and technological improvements to be done in EU agriculture to increase its competitiveness and effectiveness.
Agriculture has a strong link with rural social and economic development. Agricultural business is not only about investments on technologies and increasing market share, it has to take into account different social conditions – availability of employees, education and experience of employees, common social and economic development in region were the farm is located. Investments in technologies are important to increase effectiveness and productivity of farms. Political will and action must be involved to ensure clear conditions for farmers on CAP 2014-2020 implementation.
Opportunities for increasing EU competitiveness in global market are to implement political will and as additional vision for CAP of seven year period develop CAP for next 20-30 years. Long term vision will ensure purposeful improvements in any internal or external challenge. There must be a vision of common agricultural policy with common EU offer for global market. Each Member state must be a part of common EU and the CAP funding must be used to promote socio-economic return for all EU inhabitants.

CONCLUSIONS

Common Agricultural Policy (CAP) has created economical strengths over past years. To improve and develop EU agriculture it must solve the weaknesses that include also social, political and technological improvements.

CAP should be focused on developing common agriculture in Europe with increasing all Europe competitiveness in global markets.

EU must use all its strengths to keep its prime position in global trade – agriculture and food production has potential if all EU market will cooperate as single supplier instead of 28 internal competitors.

CAP should be concentrated to strengthen EU member states as single and strong region to meet global needs and challenges. Mutual competition between member states weakens EU position in world trade.

CAP budget must be used for increasing knowledge on agriculture and entrepreneurship for small farmers and productivity for small farms.

CAP should support increase of productivity for small semi-subsistence farms that could rapidly increase total volume of production in EU. Increase productivity for small farms together with developing cooperatives could become an economical growth for EU economy and its export markets. Small farms would save jobs and stop rural depopulation.

ACKNOWLEDGEMENTS

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AN AUTOREGRESSIVE MODEL TO ESTIMATE THE IMPACTS OF PRICE SHOCKS ON FEED PRICES

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Abstract. *The volatility of agricultural commodity market has increased in the recent years. The goal of this paperwas to estimate how changes in the prices of protein-rich and energy-rich crops impact pig and poultry feed prices. A first-differenced AR1 model to explain monthly changes in pig and poultry feed prices with current and past changes in soybean mean, wheat and rapeseed prices was estimated. The results suggest that wheat prices observed 3-6 months earlier impact the feed prices. Changes in cereal, soybean meal and rapeseed prices are transmitted to pig and poultry feed prices with a delay of 2 to 6 months. Moreover, changes in cereal prices have a larger impact on feed prices than changes in soybean meal prices. The results suggest that it is more efficient to be prepared for feed price risks than to price risks of associated with individual components (such as cereals) used as to manufacture feeds.*

Key words: *Price volatility, feed, pigs, poultry, autoregressive model.*

INTRODUCTION

The volatility of agricultural commodity market has increased in the recent years. It may increase also in the future as public market interventions are gradually withdrawn and climate change increases the likelihood for adverse supply shocks in the sector [1]. Volatility of prices of has generated a wide array of analyses and policy prescriptions. Wright [2] reviewed a number of studies and concluded that recent price spikes are not as unusual as many discussions imply. Further, the balance between consumption, available supply, and stocks seemed to be as relevant for the understanding of these markets as it was decades ago. Though there is much to be learned about commodity markets, the tools at hand are capable of explaining the main forces at work, and of giving good guidance to policymakers confronted with a bewildering variety of expensive policy prescriptions [2].

Livestock markets are often criticized for price rigidity. As livestock production process takes time, it can be costly for producers to suspend production unless the fattening pig stock is ready to be marketed. One implication of this is that if producers are faced by a strong market shock resulting in falling meat prices while input prices remain unchanged, may suffer large losses [4].

Increasing price volatility can further increase producer incentives to learn how prices behave and how the risks could be managed. The transmission of price signals in the agricultural commodity markets, such as cereal markets, have been studied frequently [e.g. 4, 5]. However, very little is known about how market shocks in the cereal, soybean and other markets are transmitted to feed prices. Feed price shocks are important to the livestock sector, because in the pig and poultry sector feeds can represent over 60% of production costs of meat and eggs.

This paper focuses on the volatility and dynamics of feed prices. The goal was to estimate how changes in the prices of protein-rich and energy-rich crops impact pig and poultry feed prices. In addition, the goal was to discuss about feed price risk management.

MATERIALS AND METHODS

Cereals (mainly barley and wheat), soybean meal and rapeseed are important sources of energy and protein in livestock feeds. Hence, their prices can have major impact on feed prices. Wheat price was used to indicate cereal prices (based on statistical testing, wheat price is a better indicator than barley price). Soybean meal, which is imported usually via Rotterdam or other major ports in Europe, and rapeseed meal prices were used to represent the prices of protein-rich feed ingredients, although rapeseed oil is also used as a source of energy in feeds.

Table 1

Descriptive statistics of the data (2000-2014)

	Mean	SD
Soybean mean price[1]	0.6854	0.1868
Pigfeed price	0.9794	0.0944
Poultry feed price	0.9917	0.0773
Wheat price	0.9276	0.1901
Rapeseed price	0.9259	0.2257

Source: Calculated based on data provided by Statistics Finland, except soybean meal price calculated based on the data obtained from the World Bank. All price indices are real prices (January 2014) represented in Euro terms and calculated to the reference January 2014=1.

[1] Soybean meal (any origin), Argentine 45/46% extraction, c.i.f. Rotterdam.

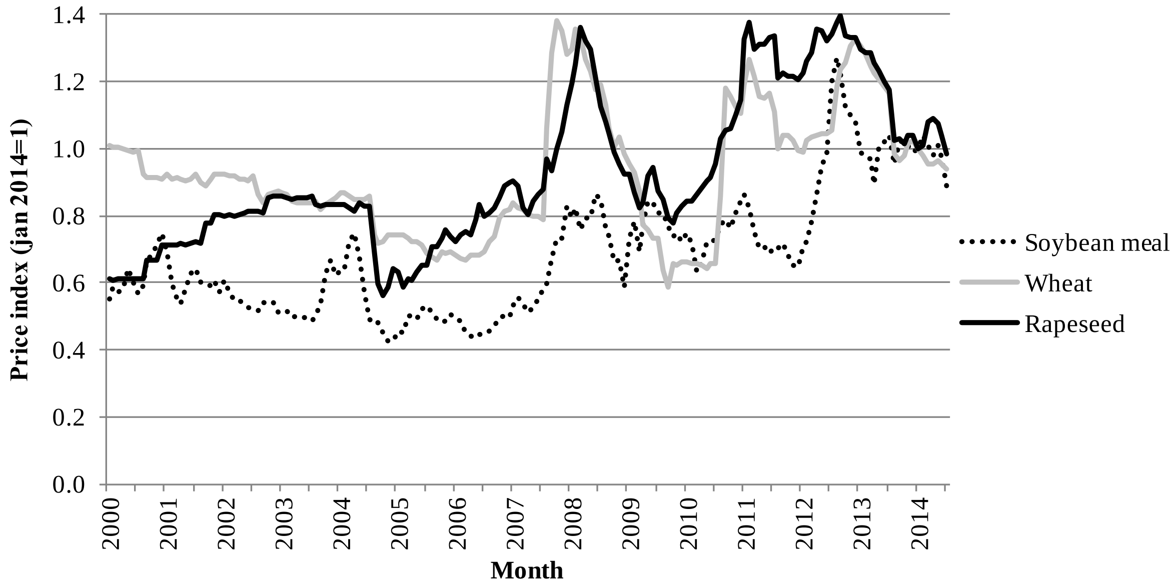

Figure 1. **The development of whear, rapeseed and soybean mean (CIF Rotterdam) in Finland (real prices deflated to January 2014 price level)**

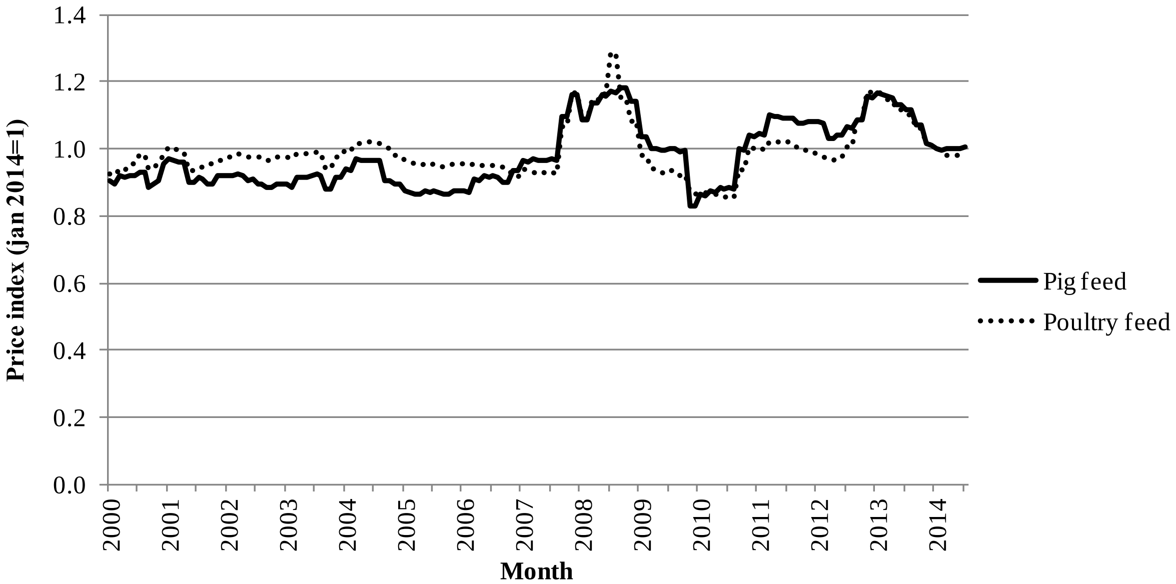

Figure 2. **The development of feed prices in (real prices deflated to January 2014 price level)**

Soybean meal price (c.i.f. Rotterdam beginning 1990) was obtained from the World Bank (Commodity Price Data , The Pink Sheet) and converted to euros by using official currency rates provided by the European Central Bank. Pig feed, poultry feed, wheat and rapeseed price indices were obtained from statistics Finland. All price indices were deflated to January 2014 by using consumer price index provided by Statistics Finland. Finally, the base of all price indices were converted to so that January 2014 was represented by index value 1.

Figures 1 and 2 as well and Table 2 show that the prices of pig and poultry feeds as well as soybean meal, wheat and rapeseed correlate with each others. All correlations in table 2 are statistically significant. Especially wheat price tends to correlate quite strongly with other prices. For instance, the correlation coefficient between wheat and rapeseed is 0.79. The correlation coefficients for both wheat and rapeseed prices with feed prices are higher than 0.5 whereas the correlation coefficients for soybean meal prices with feed prices are 0.42 and 0.29.

Table 2

Correlation coefficients between deflated prices of pig and poultry feed, soybean meal, wheat and rapeseed, pigmeat, poultry meat and eggs

	Pig feed	Poultry feed	Soybean meal	Wheat	Rapeseed	Pigmeat	Poultry meat	Eggs
Pig feed	1.00	0.96	0.42	0.73	0.67	0.63	0.67	0.66
Poultry feed	0.96	1.00	0.29	0.67	0.54	0.65	0.72	0.59
Soybean meal	0.42	0.29	1.00	0.60	0.71	0.38	0.36	0.68
Wheat	0.73	0.67	0.60	1.00	0.79	0.62	0.62	0.74
Rapeseed	0.67	0.54	0.71	0.79	1.00	0.45	0.49	0.73
Pigmeat	0.63	0.65	0.38	0.62	0.45	1.00	0.90	0.65
Poultry meat	0.67	0.72	0.36	0.62	0.49	0.90	1.00	0.75
Eggs	0.66	0.59	0.68	0.74	0.73	0.65	0.75	1.00

The prices of feeds and feed ingredients correlate quite strongly and are likely to be non-stationary. Hence, a first-differenced AR1 model to explain monthly changes in pig and poultry feed prices with current and past changes in soybean mean, wheat and rapeseed prices was estimated. Without using the differenced form, there would have been a serious autocorrelation problem in the time-series model.

The following generic models were estimated for both fig feed price and poultry feed price:

$$P_t - P_{t-1} = \alpha + \sum_{i=1}^{6}\{\beta_i(S_{t-i} - S_{t-1-i}) + \gamma_i(W_{t-i} - W_{t-1-i}) + \delta_i(R_{t-i} - R_{t-1-i})\} \text{ for } t = 1{:}T, \quad (1)$$

where P is feed price index (pig feed or poultry feed), t is time index running from 1 to T time periods, α, β, λ and δ are parameters to be estimated, S is soybean meal price index, W is wheat price index, R is rapeseed price index and i is time lag considered. The feed industry in Finland is using market instruments such as futures contracts in the Chicago board of trade to protect their inputs costs for the next 3-6 months against major price shocks which may occur unexpected in the World markets. There may also be a delay between the purchase and use of inputs such as cereals or imported protein meals. Hence, price changes in the cereal and protein meal markets may have a lagged impact on feed prices.

For methodological issues [see e.g. 6]. The equations were estimated with Maximum likelihood method by using Matlab econometrics toolbox..

RESULTS AND DISCUSSION

The models explained less than half of variation in feed prices. This implies that there is a lot of unexplained variation. In other words, in the short term other factors than only grain, soybean meal and rapeseed prices impact how feed prices evolve. However, when the models were applied for six successive months in order to forecast prices up to 6 months period in the future, as much as 75.8% of variation in poultry feed and 69.2% of variation in pig feed price could be explained by the models.

The results suggest that wheat prices observed 3-6 months earlier impact the feed prices. However, for soybean meal price the lag is only 3-4 months and for rapeseed meal only 2-3 months (Table 3). For instance, when soybean meal price increased between *t*-4 and *t*-3 by 10% (from January 2014 price level), this resulted in poultry feed price to increase by 1.14% and pig feed price by 1.04% between *t*-1 and *t*. Furthermore, 10% increase in wheat price between *t*-6 and *t*-5 resulted in 2.21% increase in poultry feed price and 1.94% increase in pig feed price between periods *t*-1 and *t*. The impact of rapeseed price was of similar magnitude.

The data shows that although the standard deviations of soybean meal, wheat and rapeseed are 0.19, 0.9 and 0.23, their coefficients of variation are 27%, 20% and 24%, respectively. By contrast, the coefficients of variation were only 8% and 10% for poultry and pig feed prices. The variation of wheat and soybean meal prices are of the same magnitude but wheat price has larger coefficients estimated in the models than soybean meal price. Hence, the results suggest that the volatility of wheat price causes approximately twice as much variation in feed prices than the volatility of soybean meal price. In this respect it is more important to manage wheat than soybean meal price risk.

Table 3

Maximum likelihood ar1 serial correlation Estimates

Dependent variable	Poultry feed price$_{t-1=>t}$		Pig feed price$_{t-1=>t}$	
R-squared	0.422		0.334	
Log Likelihood	200.770		201.094	
Number of observations	169		169	
Variable	Coefficient	p-value	Coefficient	p-value
Rapeseed price$_{t-3 => t-2}$	0.226	0.000	0.126	0.004
Soybean meal price$_{t-4 => t-3}$	0.114	0.002	0.104	0.006
Wheat price$_{t-4 => t-3}$	ns	ns	0.074	0.024
Wheat price$_{t-6 => t-5}$	0.221	0.000	0.194	0.000

Based on the estimation data, the standard deviations of monthly changes in poultry and pig feed prices were 0.031 and 0.29 respectively. Corresponding standard deviations of fitted price changes were 0.020 (poultry feed) and 0.017 (pig feed), whereas the standard deviations of unexplained variation in monthly price changes (i.e. the model's residual) were 0.024 in both model. Hence, even if all variation in the feed prices were eliminated by reducing the volatility of wheat, soybean meal and rapeseed prices to zero, the price volatility of pig and poultry feeds could be reduced by less than 25 %.

CONCLUSIONS

The results suggest that changes in cereal, soybean meal and rapeseed prices are transmitted to pig and poultry feed prices with a delay of 2 to 6 months. Hence, livestock farm's production costs do not increase or decrease instantaneously even if cereal or soybean meal prices would increase or decrease rapidly. Moreover, changes in cereal prices have a larger impact on feed prices than changes in soybean meal prices. Because a lot of variation in prices remained unexplained, it is more efficient to be prepared for feed price risks than the price risks associated with individual components (such as cereals) used as to manufacture feeds.

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YOUTH LONG-TERM UNEMPLOYMENT PROBLEMS AND INTEGRATION INTO THE LABOUR MARKET

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Abstract. *The youth long-term unemployment problem is one of the main tasks to deal with at European Union level. Also that kind of adjustment needs to be at Latvia's government level because in our country, there are demographic problems and more young people are leaving our country with the desire to find a well-paid job. Many young people choose to acquire a profession that can help to carry out the work in foreign countries, such as engineering technicians, doctors, dentists, chemists. After the university graduation, they could go abroad and proceed their master's studies there, thus having more opportunities to find a well-paid job and build career prospects.*

As it is known, the youth long-term unemployment is a long-drawn economic problem in Latvia and in other European countries, for example, in Spain, Greece etc., because there is not paid enough attention for solving problems in a long-term, which promotes the youth's long-term unemployment. A large segment of employers prefers to employ more experienced and educated persons than young people or employ young people, paying them an inadequate salary for the same job responsibilities as an adult worker.

The present research of the authors are directed towards the youth long-term unemployment reduction and provides a detailed analysis of the situation and problems in youth labour demand from employers of different regions of Latvia.

This research is based on theoretical findings, research results of expert interviews, as well as on views on the future vision by employers.

Key words: *youth long-term unemployment, youth integration, social inclusion*

INTRODUCTION

The new generation's successful integration into the labour market, the creation of innovative ideas and the realisation of the business, which will provide the new generation's future prospects internationally, are substantial. The negative aspect contributing to the world's economic globalization is the outflow of youth's intellectual capital to abroad, which actually takes away Latvia's young professionals and decreases the evolution of innovative products and services. Nowadays it is known that the realisation of innovative products and services is one of the preconditions for successful development of business at international level, which provides the greatest part of the company's income [8].

The authors consider that nowadays there are more fields that are not developed in rural areas because of deficiency of financial support. In prosperous European Countries, like Belgium, Germany, France, farmsteads and agriculture and farming are more developed. In these countries, agricultural land is cultivated and profits are made. Also it is one of the possibilities for the Latvian youth, only there are needs to find a business idea, financing and self-motivation.

The authors want to highlight the need of youth long-term unemployment reduction and the importance of identifying potential solutions for alleviating the youth long-term unemployment for a long time.

The research object is the labour market situation for young people in Latvia's regions. The youth integration into the labour market is determined by employer decisions to employ young people regardless of experience and education.

The aim of the research is to understand the importance of youth long-term unemployment problem causation and to establish the view of employers on young people's integration into the labour market.

To achieve the aim, there are set the following tasks:

1) To evaluate the theoretical aspects from different authors to understand the necessity of reducing the long-term unemployment of youth;

2) To make expert interviews with employers to establish their opinion of young people's possibilities to align with the labour market, especially in rural areas.

MATERIALS AND METHODS

The following materials and methods are used to achieve the aim and fulfill the tasks:

1) Theoretical framework of the research: monographic and descriptive methods are used, also the research is based on scientific discussion of different author conclusions on youth long-term unemployment problems;
2) Research methodology: the methods of expert interviews, discussion of the results and findings are used to reach the aim.

The authors made the expert interviews to gather information on employers' opinion of young people employment in their institution and difficulties with what they are ready to face. There were made interviews with employers from the public and private sectors, for a wider vision of the labour market. The expert interviews were conducted from September 2014 to December 2014. In this paper, the authors are continuing the previous research discussion and are accomplishing the conclusions.

RESULTS AND DISCUSSION

Explanation of youth long-term unemployment problems and solutions

The potentially important attention to the youths social exclusion is drawn by foreign authors such as Room (1995), Arulampalan (2001), Kieselbach, Beelmann, Strtzl, Traiser (2001) and Hammer (2003) [2],[9],[12]. The political and economical aspects are analysed by the groups of foreign industry experts such as Audas, Berde, Doliton (2005) and Green and White (2007) [1],[7].

Active discussions on Latvia's long-term unemployment trends and issues are made by economists and researchers such as Hazans (2011) and Krasnopjorovs (2012) [10],[13].

According to authors Lee, Sissons, Balaram, Jones and Cominetti (2012), most of the long-term unemployed are significantly more likely to have low or no qualifications [15].

According to authors Gidfrey (1986) and Kwiatkowski (2005), the commonly held conviction that the unemployment is of a multi-faceted nature is an important starting point for the analysis of unemployment. It requires searching its determinants in different areas and economic processes: demand and supply side of the economy, institutional arrangements in the labour market, as well as socio-economic and demographic characteristics of individuals [6],[14].

Author Room (1995) mentioned civic integration and political participation, social protection, integration in the welfare state and interpersonal integration in family and community systems, besides integration in the labour market as core components of social exclusion [17].

Ignoring the youth employment challenge imposes not only widespread unhappiness and social discontent among youth, but also carries tremendous economic and social costs. Youth unemployment is an immense waste of human resources that could contribute to economic and social progress. An increase in youth employment would have multiplier effects throughout the economy, boosting consumer demand and adding tax revenue [18].

The main factors affecting youth employment are determined:

– Job/employment creation- the main factors that influence job creation, which
– encompasses aggregate demand economic growth (macroeconomic policies, appropriate regulations and the promotion of entrepreneurship and enterprise creation and development);
– Working conditions – the factors that impact on working conditions such as legislation, regulations and the business cycle;
– Employability – the factors that address employability, such as education and training, work experience, labour market information and services and institutional structures to integrate youth into the labour market [18].

Explaining differences in youths' transition into employment needs to take into account, first, demographic developments and economic growth, and second, the interplay between these dynamics and long-standing institutional patterns, in particular regulatory provisions influencing the supply of flexible or permanent jobs as well as education and training policies. Both general education at schools as well as different forms of vocational education and training, either at schools or on the job or combining both elements in a dual apprenticeship, are necessary preconditions for the employability and productivity of young people [5].

Youths' unemployment, as well as the situations in which the youths are forced to give up seeking a job, or to work in inadequate conditions have a strong impact on the economy of a society, on the families of these youths, and on their personal and career development, and on the society at large, as well. The lack of a decent job, in particular if it occurs at a short-time after graduating some educational form, can compromise the future of an individual, his/her career perspectives, and very often it can lead to social exclusion [3].

Unemployment among youths generates long-term effects both on the income and on the stability of the job, because youths affected by unemployment have a lower level of credibility and are not as trusting and flexible about employment opportunities and thus, developing with more difficulties from the professional viewpoint [4].

Within the framework of potential efforts and strategies to boost employment and job creation for young people, entrepreneurship is increasingly accepted as an important means and a useful alternative for income generation in young people [11]. As traditional job-for-life career paths become rarer, youth entrepreneurship is regarded as an additional way of integrating youth into the labour market and overcoming poverty. Supporting this shift in policy is the fact that in the last decade, most new formal employment has been created in small enterprises or as self-employment [16]. Given global demographic trends, it is important that the social and economic contributions of young entrepreneurs are recognized. Entrepreneurship can unleash the economic potential of young people [18].

The authors believe that this statement most applies to potential to reduce unemployment in rural areas.

The authors summarized findings from different authors who researched youth long-term unemployment; the common denominator is that the youth long-term unemployment is directly affected and is related to social inclusion into and exclusion from society and that means also inclusion into the labour market because social aspects affect the individual's financial situation, career possibilities, education level, future developments and progress in society.

Expert opinions of youth's opportunities for integration into Latvia's labour market

To understand the situation of youth employability from entrepreneurs and executives of state institutions, the authors made interviews with 10 experts from different sectors. The previous paper examined the opportunity for young people to adapt to the labour market and the opinions of entrepreneurs and representatives of institutions (hereinafter mentioned as the experts) on youths' employability, their career possibilities, the demanded education level and necessary skills for employment.

This article will cover the views of employers on variety mobility measures for young people for a successful integration into the labour market. In the expert interview, each of the experts was asked 12 questions. The first paper discussed 7 questions. Table 1 demonstrates the information on the respondents' industry and location.

Table 1

Information of the experts from Latvia's cities and rural areas (n=10)

Sector	Represented industry	City/ Rural area
Experts from the private sector:	Auto parts retail	Lielvarde and region
	Retail Business	Lielvarde
	Market and social researches	Office in Riga, working in all regions of Latvia
	Construction industry	Office in Jelgava, working in all regions of Latvia
Experts from the public sector:	Pre-school education	Jumprava, Lielvarde municipality
	Education	Skaistkalne, Vecumnieku municipality
	Social sector and education	Jelgava
	Tourism	Jelgava
	Sewing services	Jelgava
	Research	Jelgava municipality

Source: authors' interview results

The acquired expert answers were summarised in two parts – the public sector (education, the social sector, research and tourism) and the private sector (market and social researches, auto parts retail trade, the construction industry and retail business).

Experts were asked to answer the question – "*What is your assessment of the youth mobility arrangements of the State Employment Agency implemented with financial support from the European Union's Funds through which part of youths' wages are paid? providing that the employer employs a young person involved in the project for a certain time period*". On this question, 5 of 6 experts answered positively. Some of the experts from the public sector mentioned that:

– They have already involved young people in summer jobs;
– In this summer it was not possible to employ young people because there was no well-prepared project;
– They thought that it was an option for a young person to gain experience;
– If a young person is provided with a job and he or she does not have to go to and work in another state, then we are supporting that mobility arrangements.

One of the respondents from the public sector answered that they perceived these arrangements as semi-positive.

The experts from the private sector mentioned that:

– They perceived it as positive because under the State Employment Agency Programme, young people acquire the skills.
– The negative aspect is that it is not intended to reward superiors for conducting practical training.
– We do not use it, but we hire young people, even though they have not yet got certain professions as required for the replacement of staff because many employers are retiring. Current employees are teaching the young people the necessary skills and abilities;
– One of the respondents answered that his attitude is neutral and he has no opinion on this question.

In order to identify the views of the experts on specially educated youth employment for their industry, the experts were asked to answer the question – *"Do you prefer to employ the young people specifically prepared for your industry if a young person is specially prepared for the job duties? The young people will be trained for performing the specific job duties within European Union projects"*. The respondents from the private sector mentioned that in our industry it is not possible to train and prepare young people in projects, we are requiring the education at university level. A respondent from the public sector answered that in theory "yes", it is possible, for example, during the summer, when there are more tourism activities, but we need to understand if our budget allows it. Other respondents from both the private and public sector responded positively.

In the previous paper, the authors asked the *experts to mention the most important measures for state institutions to stabilize the youth labour market situation in the future.* Some of the experts mentioned that the tax preferences for employers and the tax preferences for young people who are studying or having social instability and also additional bonuses for employers would promote the employment of employ young people in their institution or enterprise.

According to previously mentioned measures, the authors asked a direct question – "*Are incentives in the tax area could affect your decision to accept the young candidates for the vacant job instead of experienced applicants?"* An expert from the public sector answered negatively, principally, the skills of young people need to be in line with the requirements of industry. Other 9 experts from both the public and private sector responded positively.

It is well known that according to European Union planning documents, one of the possibilities how to deal with youth long-term unemployment is to develop the young people participation in projects directed to entrepreneurship development in rural areas and self-employment. To find out what are the opinions of employers, the authors asked the experts to give answers to the question – "*What is your assessment of the potential of young people to start their own business in today's economic situation?"*

– If the young people have an idea, knowledge, desire, energy, necessary resources, then there are possibilities;
– To start a business it is not difficult, but to stay on the market, to grow and make a profit it is very hard;
– The business start-up opportunities do not depend on the economic situation, but are dependent on the personality type;
– They thought that there are options, such as a bike rental in Jelgava district, which could be the beginning of entrepreneurship;
– In Jelgava, there is a good opportunity, there is a business incubator, a center of expertise, an active trade association and a knowledge and technology transfer center in Latvia University of Agriculture.

- The possibilities are wide-ranging, but are the young people able to use them, that is the question. Is there sufficient understanding?;
- Not enough support.

The authors consider that in general the employers are positively disposed to youth entrepreneurship development, as the main emphasis is placed on the youth's desire to start a business, using a variety of support tools, on the individual's personal traits and understanding and knowledge of the area in which to pursue and develop the business.

According to the previous question, the authors wanted to understand the expert opinion of business support in Latvia. All of the experts were asked to answer the question – *"Do you think that the business support instruments for start-ups are provided at a sufficient level in Latvia (for example, micro-credit programmes, start-up programmes, mentoring, business incubators, etc.)?"*

The experts from the public sector considered that:

- It is possible to get the main support from a programme provided by "Altum" (The remark of the authors- in past it was Hipoteku Bank, which was responsible for crediting business start-up programmes, micro credit programmes and rural support programmes);
- Not completely thought out, it is for young agriculturists, but there is need for more support for other fields;
- For university students, yes, but for students from professional schools with professional education- not;
- Young people are afraid to start a business, elderly too;
- There is need for tax relief for at least the first 2 years;
- If there are a few new enterprises that are working and keeping in the market for a long time, then there is not providing with all instruments.

The experts from the private sector were reluctant in relation to this question. One of them considered that these instruments were already like a big step forward, 10 years ago there were not such possibilities, maybe not every young individual was informed of these instruments and did not use them enough. On this question, 2 of the experts answered positively and one negatively.

The authors summarise that in Latvia in general, the main problem is financial support and insufficient information on business support instruments and possibilities contributing to insecurity of young people to start his/her own business.

CONCLUSIONS

According to different author scientific researches, attention is paid to the youth long-term unemployment problem in all European countries. There was not found the common determinant from industry experts how to deal with that kind of problem. There are mentioned several activities and realized unemployment support programmes, such as training, practice, social benefits if youths are attending courses etc., but all these instruments make an impact in a short-term period.

The youth integration into the labour market is very important for young people's future options; also, it has a significant role in the country's revenues, competitiveness and development.

There is need to determine long-term instruments to struggle with youth long-term unemployment and to provide the future possibilities for young people. To realize this protracted problem in a long-term, most of the experts emphasize that governments and state institutions need to provide young people with exhaustive information on support instruments, for example, one of the kinds of support can be a cohesive environment between universities, professional schools and employers. According to the expert interviews, it is understood that if young people have motivation, practical skills and want to work, employers are ready to employ them, but with one note, also entrepreneurs and state institutions need financial support for new work places.

According to the survey results, the authors consider that young people have potential if they are ready to study, to struggle with administrative and financial problems, and to struggle for clients, as well as the volume of service and product sales.

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MARKETING OF AGRICULTURAL PRODUCTS AND THE USE OF MOBILE PHONES AMONG FARM-HOUSEHOLDS IN GHANA AND UGANDA: A SURVEY

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Abstract. *New market information systems and services based on mobile communication technologies create opportunities to reduce the cost of linking buyers and sellers, thus developing opportunities to reduce poverty. Because market situation changes constantly, it is particularly important to have up-to-date information on the markets. The goal of this study was to examine how small-scale farmers in Ghana and Uganda use marketing channels, what is the choice of buyers and how they use mobile phones to obtain market information. Similar farm-household surveys were carried out separately in Ghana (1290 households) and Uganda (1440 households) in 2011-2012. Each household was visited by an enumerator collecting information on household's demographic characteristics, assets, marketing patterns and incomes. The results suggest that surveyed farm-households in Ghana and Uganda had a good choice of buyers for their agricultural products. The price of product and the payment conditions were key factors determining the buyer. Although majority of farm households owned a mobile phone, they were not widely used to obtain market information. Hence, mobile technologies have the potential to generate additional income to farm households in these countries.*

Key words: *Market access, farming, Africa, mobile phone use.*

INTRODUCTION

The performance of local markets plays a decisive role in promoting economic growth and reducing poverty in Africa. Improvements in infrastructure and market performance are important when providing small-scale farm households with better opportunities to gain income. An important aspect related to the markets is farmers' fair access to markets, which includes the process of finding buyers to the products, finding price information and negotiating prices. Because market situation changes constantly, it is particularly important to have up-to-date information on the markets.

More efficient market information systems can reduce agricultural marketing margins and price volatility and increase prices that farmers are able to receive upon selling their products. New market information systems and services based on mobile communication technologies create opportunities to reduce the cost of linking buyers and sellers, thus developing opportunities to reduce poverty. Previous studies have shown that such mobile technologies have, at least in some markets, the potential to benefit farmers [e.g. 1, 2].

The goal of this study was to examine how small-scale farmers in Ghana and Uganda use marketing channels, what is the choice of buyers and how they use mobile phones to obtain market information.

MATERIALS AND METHODS

Similar farm-household surveys were carried out separately in Ghana and Uganda. The surveys covered 1290 Ghanaian farm-households which were selected by stratified random sample of northern Ghana, and 1440 Ugandan farm-households which were selected by stratified random sample from 8 purposively selected districts. In Ghana the survey was carried out in October-December 2011. In Uganda the survey was carried out in September-December 2012.

To collect the data, each household was visited and interviewed by an enumerator. For each household, they collected information on issues such as education and literacy, main and secondary activity, land use, crop mix, the use of inputs and the ownership of production assets, yields to each crop and animal type, non-farm activities, access to credit, access to mobile phones, household decision-making, participation in community organizations, and allocation of time. The data were summarized and descriptive statistics were produced.

RESULTS AND DISCUSSION

The survey results suggest that in both countries, the median farmer sells slightly more than one-third of their crop output. In both countries, about 90% of sales are to traders, with consumers accounting for most of the rest. Direct sales to processors, exporters or supermarkets are rare in both countries. Also cooperatives play a negligible role in crop marketing in both datasets as less than ten per cent of interviewed farmers had ever sold their crop through a cooperative or a farm organization. In Uganda, most (84%) sales took place at the farm whereas in Ghana most sales (74%) involved the farmer bringing the product to market. These results may be due to the impact of smaller marketing revenues or lower population density in the northern Ghana than in Uganda.

Regarding the magnitude of crop sales, the data did not show clear distinction between “subsistence” and “commercial”. In Uganda, a median interviewed households sold 38% and in Ghana 34% of their crop production. In Uganda only 14% did not sell any crop products whereas in northern Ghana 28% of farmers did not have any crop sales. A large majority of interviewed farmers were able to choose between multiple traders. Regarding the main commercialized crop, 26% of Ugandan and 44% of Ghanaian households were able to choose at least among six buyers. Generally (55% in Ghana and 68% in Uganda) the buyer was selected select based on the best price offer. Either the best price or the possibility of immediate payment was decisive criterion for altogether 85% farmers. Debt or other obligations were rarely mentioned as the criteria to choose the buyer.

A majority of farm households in both countries owned mobile phones (62% in Ghana and 72% in Uganda), but only about one-quarter of owners used it to gather market information. According to a probit model explaining the mobile phone ownership, households owning mobile phones tended to have more members, higher income, and more education than households not owning the phone. Sex of head of household was did not significantly determine the ownership after controlling for the effect of other factors. Less than half of farmers in both countries felt well-informed about agricultural prices, and this share was even smaller among small-scale farmers

CONCLUSIONS

The results suggest that surveyed farm-households in Ghana and Uganda had a good choice of buyers for their agricultural products. The price of product and the payment conditions were key factors determining the buyer. Although majority of farm households owned a mobile phone, they were not widely used to obtain market information. Hence, mobile technologies have the potential to generate additional income to farm households in these countries.

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GENDER DIVISION OF FARM WORK AND OCCUPATIONAL INJURIES

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Abstract. *Farm work, particularly with livestock, exposes farmers to adverse health outcomes, which may result in loss of work ability and early retirement. We investigated the gender division of farm work and occupational injuries in the Finnish farming population covered by the mandatory workers' compensation insurance. Claims data were augmented with data from a postal survey containing questions about the relative division of farm work between male and female farmers. Over the 5-year study period (2009-2013), the average number of farmers was 73,870 (males 67% and females 33%) with a total of 23,004 compensated occupational injuries (males 75% and females 25%). Claims most frequently involved work tasks related to animal husbandry. Altogether 319 usable responses were received to the postal survey (12.9% response rate). Farm work time and occupational injuries differed by gender. In general, crop production, construction work, forestry work, and few other farm work tasks including repair and maintenance of machines, and farmstead and road maintenance were male-dominated, whereas females took the main responsibility for domestic work and caretaking work as well. Animal husbandry was divided more evenly between males and females with their relative work contributions of 56% and 44%, respectively. Animal husbandry-related injuries were divided correspondingly between the genders (males 57% and females 43%) but all other types of injuries occurred mostly to males. While many studies have shown that male farmers have a much greater risk of injury than females, our study shows that given equal work time, the risk of injury was also equal. Therefore, rather than a risk factor, gender is an indicator of different work exposures in farming. This finding can contribute to better understanding of the risk of occupational injury among farming populations and could help design more effective interventions.*

Key words: *agriculture, exposure, farmer, insurance.*

THE INFLUENCE OF THE PRESIDENCY OF LATVIA AT THE EU COUNCIL ON THE DEVELOPMENT OF THE TOURISM INDUSTRY IN THE REGIONS OF LATVIA

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Abstract.*The objective of this Publication is to analyse the influence of the Presidency of Latvia at the EU Council on the indicators of the tourism industry in the regions of Latvia. Taking into consideration the geopolitical situation created as a result of the conflict between Russia and Ukraine, Latvia, especially its regions, experienced a substantial drop in the tourism indicators in 2014. For example, the occupancy rate of overnight accommodations in Riga – in 2013 the average occupancy rate was 63%, but in 2014 – only 58.66%, in the regions of Latvia – in 2013 the average occupancy rate was 52.75%, but in 2014 – 49.3%. Therefore the tourism industry looked with hope towards the anticipated Presidency of Latvia at the EU Council in the first half-year of 2015. In the preparation process of the Publication the available articles and experience of other countries and the data of inquiry of the entrepreneurs of overnight accommodations and catering industry in the regions of Latvia were analysed. The results of the research reveal similar tendencies between the experience of the presidency period in Latvia and Lithuania and can serve as basis for improvement of the situation during presidency of other countries.*

Keywords: *tourism, Presidency at the EU Council, development of tourism in regions.*

PROBLEMS OF RECORDING BIOLOGICAL ASSETS AND LEGISLATION SHORTCOMINGS IN LATVIA, POSSIBLE SOLUTIONS

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Abstract. *One of the 20th century politicians has said that the basis of the security and development of the country are accounting, supervision and electrification. From my point of view, this is applicable also in nowadays, although I'd like to add agriculture to this list.*

Why? In the modern world we simultaneously experience a rapid population growth and a decreased chance of survival. Wars, terrorism, unknown diseases, but most importantly – shortage of food. Furthermore, for example, in the European Union there is a quota system for agriculture and foodstuffs production. The United States of America supports the production of GMO or genetically modified organisms. Here we have to ask: Could it be that the food shortage is caused by completely different reasons?

The world highly values MONEY and the stabilization of the bank system. But humans cannot live on pieces of paper or metal coins. Our bodies are of a different kind. We need to have food that is healthy, rich in vitamins and wholesome.

Apparently, we have forgotten about the effective production and markets of such products. Today, people are ready to pay more for healthy and safe food. I think, agriculture in the time to come will have a stronger position in industry competition than it does today. That is why I'd like to turn back to the first paragraph of my speech – to the accounting and control. It may sound weird – agriculture and accounting – but it must be stressed that erroneous accounting causes problems, which in many cases result in the bankruptcy of agricultural enterprises.

In June 26, 2013, The European Parliament and The Council passed the directive 2013/34/EU on the annual financial statements, consolidated financial statements and related reports of certain types of undertakings, amending Directive 2006/43/EC of the European Parliament and of the Council and repealing the Council Directives 78/660/EEC and 83/349/EEC. The main goal of this directive is to reduce administrative burdens and improve the business environment. The directive's underlying principle is to "think small first". That is – to prioritize small and medium-sized enterprises.

In order to implement this directive in Latvia, the Minister of Finance in November 27, 2013, issued an order to form a work group. This group consisted of representatives from the Ministry of Finance, the State Revenue Service, members of the Association of Accountants, the Association of Outsourced Accountancy Service Providers, as well as representatives from Employer's Confederation, and Latvian Chamber of Commerce and Industry. It is evident that the work group represented the interests of all concerned parties.

Now, the work group has completed its task, and the draft law has been received by the Budget and Finance Committee for submitting it to the Parliament for first reading. Of course, the law contains many changes concerning preparation of annual financial statements, the responsibility of accountants and management. Unfortunately, the law doesn't say anything about biological assets and their evaluation.

The only mention can be found in the Terminology section: "Biological assets are animals or plants, which the company holds in order to acquire agricultural products to sell or additional biological assets. Agriculture within the meaning of this Law is also forestry, fisheries and another such basic activity, which includes the administration of animal or plant biological conversion – its growing, degeneration, production and reproduction processes."

Sadly, there is nothing more in the normative acts than the definition of biological assets and poor explanations concerning their evaluation and fair value.

Since most of the Latvian companies don't have to comply with the International Accounting Standards, then quite often businesses face the difficulty of choosing how to correctly keep accounting records in regard to biological assets and their correct evaluation.

From my point of view, in case of Latvia, we can say that in our country there are no traditions of clear and transparent accounting of biological assets. Therefore, the farmers have problems establishing a sufficient level of trust and, consequently, attracting investors. But it is important to mention that exactly these factors are what constitutes a quality management of modern farming.

The negative consequence of the lack of guidelines and criteria for evaluating biological assets in Latvia is chaotic and incomparable information about biological assets in annual reports.

Of course, the International Accounting Standard number 41 "Agriculture" can serve as a guideline. The application of this standard provides the possibility to evaluate biological assets, using equal criteria and determining fair values.

The abovementioned standard is applicable in cases when the agricultural activity is linked with

- *Biological assets;*
- *Agriculture produce at the point of harvest; and*
- *Government grants under certain conditions;*

The standard states that "A biological asset shall be measured on initial recognition and at the end of each reporting period at its fair value less costs to sell, except for the case where the fair value cannot be measured reliably."

The Annual Accounts Law, Section 55.[5] allows the evaluation of biological assets in their fair value. In order to be able to do it, one of the following parameters has to be abided by:

- *the biological asset objects have active market and permanently available market prices;*
- *it is possible for the biological asset objects with other recognised methods to specify the fair value at the current location and condition thereof.*

However, we have to take into account that there is no active market for the most part of biological assets and also there is no information about the market value of such assets. It is one of the key reasons, why the application of the fair value principle in evaluating biological assets is rather complicated.

Hence, because of the reasons mentioned above, biological assets are, in most cases, accounted in accordance with Section 26 of the Annual Accounts Law, that is, evaluated in accordance with cost of their acquisition or actual cost of production, and gradually written off.

However, by not addressing the question of determining the fair value of biological assets, we end up in a situation where the value of these assets is false, and we can't fairly evaluate the financial situation and viability of enterprise.

In current situation in Latvia we should develop a base of normative acts that would establish:

- *the possible methodology and criteria for evaluating biological assets;*
- *Suitable classification.*

If the normative acts of Latvia came closer to International Financial Reporting Standards, we could solve the problems in accounting of biological assets. Data would be comparable among different companies, and that would allow for consolidation of this information on state level. That, of course, also will result in more accurate statistics, so necessary when drafting the future development plans of the industry.

In conclusion, I want to stress once again, that, in regard to accounting of agricultural harvests and biological assets, Latvia has to develop a completely new regulatory system.

Key words: *biological assets, agriculture, normative acts, EU directive, evaluation.*

FORECASTED OUTCOMES OF LATVIAN REGIONAL POLICY'S IMPLEMENTATION IN MUNICIPALITIES

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Abstract. *The main instrument of regional policy in order to reach balanced development is formation of polycentric territorial structure so strengthening the role of regional towns in the development of surrounding territories and concentrating the support of investment in 30 development centres. Regional policy states that the concentration of capital and resources will form the necessary critical mass for socio-economic development not only in urban areas, but also surrounding rural areas, therefore mutual urban-rural interaction is very important. In the result of three scenarios, the most balanced spatial development in 2020 is estimated to be in the case of status quo scenario, which foresees the investment in development centres maintaining the existing development tendencies. However, it can be estimated that the most predictable development scenario is the third-competition scenario and balanced spatial development will not be achieved.*

Key words: *rural-urban interaction, regional policy, development, cooperation.*

INTRODUCTION

Urban-rural cooperation has been emphasized in the development planning documents at EU level since 1980s, including knowledge transfer, innovation creation and distribution, promotion of cooperation between local administrations and creation of small and medium-size city network [1]-[3]. Rural-urban interaction is considered as essential tool for polycentric development [2]-[4]. However, taking into account the significant differences between Member States – the institutional framework, economic development and cultural differences, there are not are not defined common political tools in order to achieve spatial development objectives.

In Latvia urban – rural interaction as component of spatial perspective has been emphasized in several development planning documents and legislative acts[5]-[7]. Long-term goal of Latvian regional policy foresees to "create equivalent life and work conditions to all residents regardless of their place of residence". Development planning documents foresee funding for several blocks of measures, for instance, improvement of demographic situation (EUR 2 747.70 million), provision of public transportation's availability (EUR 1 697.56 million) and fostering of economic activity (EUR 2 131.69 million) [7]. As a result of reaching this aim, the development pace of undeveloped regions will be increased and balanced habitation structure of residents will be fostered. Measures to reach the goal foresee the concentration of public investment support in development centres of national and regional importance. Concentration of investments will create critical mass for the creation of significant growth as a result the situation must improve not only in development centres, but also in surrounding territories. However, there is not provided instruments which can encourage cooperation and positive interaction that benefits residents in both areas. Taking into account non-mandatory cooperation and lack of growth transfer instruments and funding, objectives of regional policy may not be achieved in planned period, deepening socio-economical differences in Latvian administrative territories. The aim of this research is to forecast outcomes of regional policy's implementation in municipalities in Latvia in scope of rural-urban interaction and cooperation.

MATERIALS AND METHODS

Evaluation of scenarios was carried out to reflect the impact of selected measures in reaching regional development policy aims on balanced spatial development as the main goal of regional policy. Evaluation of situation was carried out for medium-term development prognosis for 2020. Significant part of public investment support has been estimated from EU fund programmes, therefore no sooner than in 2020 the first expected results reflecting real benefits and changes can be analysed. Possible socio-economic development tendencies of municipalities have been set in the first part of evaluation based on resultative indicators defined by National Development Plan 2020 (NDP 2020). Values of socio-economic indicators in development centres were respectively altered, taking year 2011 as the base year. The indicators of other municipalities were calculated according to the expected three scenarios.

1. *Status quo scenario* characterises the situation in which concentration of investments in 30 development centres improves their socio-economic condition in accordance with expected indicators stated by NDP 2020, while other municipalities continue to have the current development tendencies.
2. *Cooperation scenario* – investments in development centres improve their socio-economic growth, which is transferred to surrounding territories, so stimulating the development of all Latvian municipalities. However, the pace of development centre growth cannot be equal to the pace of surrounding territory growth because of several reasons. First of all, the areal of regional development centre impact can be different both because of physical and social infrastructure. Secondly, 30 development centres border with 77 municipalities, while 12 municipalities do not have formal border with development centres. Taking into account the above mentioned, the growth for bordering municipalities of republican cities has been estimated at 70%, but for other municipalities – at 50% of the growth pace of development centres. Differentiated rate has been chosen, because there is a bigger concentration of critical mass in a republican city, which gives higher influence intensity on surrounding territories in comparison to the development centres of regional importance.
3. *Competition scenario* reflects the most negative situation – concentration of investments in development centres improve their socio-economic situation, but growth is not transferred to surrounding territories, so stopping or even worsening the socio-economic development of these territories. Taking into account the tendencies of population decrease, this indicator submits to the changes according to the estimated situation in 2020 set by NDP 2020.

In the second step, factor analysis was conducted for those indicators characterising demographic situation and economic activity, which correspond to the motive of NDP 2020, which is *economic breakthrough*. Obtained results of factor analysis were compared by evaluating the influence of regional policy on balanced territorial development, which estimates that differences among municipalities should be lessened. Results of factor analysis have been evaluated by grouping municipality factor values in levels, which show the differences among regions: *clear* differences in comparison with the average level of Latvia, if factor values are greater than 1 or less than –1; *slight* differences – factor values are from 0.5 to 1 or from 0.5 to –1; *average* situation, if factor values are from – 0.5 to 0.5, which characterise the homogeneity of municipalities. Balanced socio–economic development in municipalities characterizes maximum homogenous factor values, but as the number of those municipalities, which have clear high or low factor values, spatial structure becomes heterogeneous so creating basis for disbalanced development.

In the third stage, cluster analysis, municipalities are grouped based on the values complex factors, and then a cluster was set with the situation that can be valued most positively as well as cluster with the most negatively valued situation for every factor. When conducting complex grouping of municipalities, those fields have been identified, because of which a particular municipality has been included in cluster with the most positive or negative situation.

RESULTS AND DISCUSSION

Urban-Rural Cooperation. Cooperation and partnership among the municipalities is an important element in order to create balanced regional development. As a result of scientific discussions[8]-[18], spatial dimension as well as the importance of providing balanced urban-rural interaction has been included in development planning at international and local level. Sustainable administration of urban-rural interaction is directly dependant on the attitude of local administration structures, when developing territory development strategies, which can generate cooperation or exactly the opposite – conflicts among territories. Benefits are both economic and social, when deliberately forming urban-rural partnership and using existing linkages or forming new ones [8]-[12]. As a result of urban-rural cooperation, polarisation and stratification are lessened; local problems are solved in wider and more strategic level. Urban-rural cooperation promotes the integration of knowledge, ideas, innovation and entrepreneurship in rural economy and society [12]-[16]. Veneri [14] points out that urban-rural interaction is influenced by region's economic, spatial and administrative structure. Regional aspect has been reflected also in Čaplikas [9] researches in Lithuania – it has been concluded that if significant regional differences exist as a result of urbanisation process, then different interaction models must be created for each region separately, taking into account the spatial structure, agricultural development, availability of services and the level of urbanisation.

Forecasted scenarios in Latvia. In total 21 indicators was used to evaluate situation. In factor analysis 6 factors were determined. Residents' income (including Personal Income Tax amount in the municipality budget per 1 resident, share of residents in the pre-employment age, density of population and share of residents after the working age), Residents' structure (demographical load, share of residents in the working age and share of residents after the working age) and Number of residents (number of residents, changes in number of residents) describes demographic situation. Meanwhile economic activities' in municipalities were characterized by Employment (number of employed, number of employed in public sector and private sector, gross salary and number of individual merchants per 1000 residents), Salary (gross salary in total, in public sector, number of companies per 1000 residents and unemployment level) and Basic forms of economic activity (number of economically active market sector statistical units of per 1000 residents, number of self-employed per 1000 residents and number of peasant and fishermen farms per 1000 residents)

Status quo scenario in the regional development of Latvia characterizes situation in 2020, if the support of public investment is concentrated in development centres of national and regional meaning, but other municipalities will continue existing development tendencies. Situation reflects post crisis growth period, however, natural growth of population and net migration remains negative.

The estimated values of indicators characterising demographic situation show disbalanced situation – only less than half of municipalities have homogeneous values, which show the disbalance of spatial development. Factor values characterising economic activity are homogeneous in the field of workplace offer in private and public sector, while municipality indicators are significantly different concerning number of employees and registered types of commercial activity.

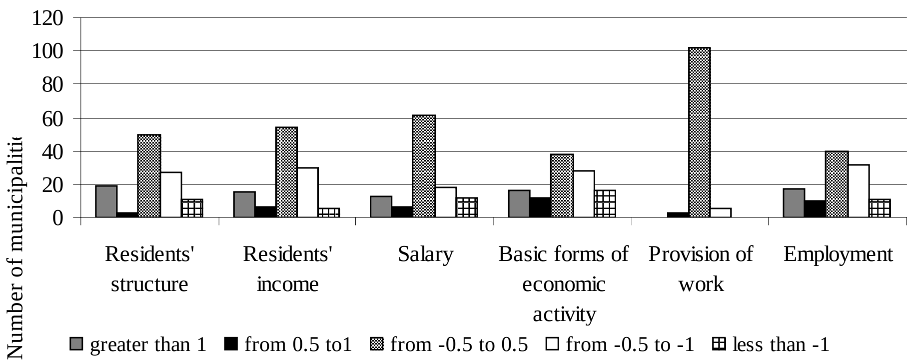

Fig.1. **Estimated number of municipalities in groups of factor values in the scenario of *status quo***

As a result of cluster analysis, positive development has been estimated for 61 municipalities in 2020 – favourable age structure (7 municipalities), high level of resident income (11 municipalities), high employee remuneration (11 municipalities), high economic activity (14 municipalities), high number of employees both in private and public sector (19 municipalities). All development centre municipalities of regional importance have been estimated to have positive development, but bordering municipalities of republican cities are differentiated – bordering municipalities of Riga have been characterised with clearly positive and high values of socio-economic indicators, while municipalities, which are located in other regions, have negative values of indicators.

Clearly negative situation could be in 29 municipalities, the indicators of which are in the groups of indicators characterising the lowest demographic situation and economic activity. Relatively negative situation can be observed in municipalities, which are located in Zemgale and which focus on agricultural production, which was not subject to development forecast. It shows that the specialisation of municipalities can be evaluated as positive, however, it raises the risk, that in case of negative changes, for example, consumption of agricultural production in the market, these municipalities could have important reduction of growth rate. Forecast obtained in cluster analysis reflects situation in 2020 and shows that by continuing the existing growth rate, it is possible to balance spatial development, because positive development tendencies could be estimated in 61 municipalities. The most significant differences among municipalities will exist because of different number of population, as a result also because of different number of employees and economic activity.

Scenario of cooperation in Latvian regional development – the most significant element of balanced spatial structure is cooperation of territories. By concentrating the support of investments in development centres of national and regional importance and so increasing growth rates, the positive effects of socio-economic changes are transferred to surrounding territories – most often – bordering municipalities.

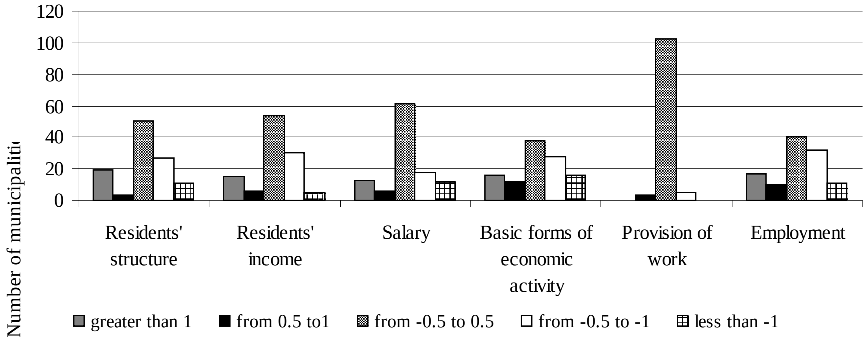

Fig.2. **Estimated number of municipalities in factor value groups according to *cooperation* scenario**

When evaluating all characterising indicator complex factors of and their values for particular municipalities, it must be concluded that significant differences exist – about half of municipalities have homogeneous demographic indicators, while others have different indicators both from positive and negative aspects. Particularly heterogeneous situation is regarding to the factor *Basic forms of economic activity*, while the factor *Provision of job* in municipality may be relatively even. By evaluating the results of factor analysis for indicators characterising economic activity, it must be concluded that there are differences among municipalities according to three factors – a significant aspect in the development of municipalities and in reaching the NDP motive – *economics' breakthrough.* Taking into account the observed differences, it must be concluded that the regional politics planned for 2020 will not reach the goal in the formation of balanced municipalities according to the scenario of cooperation, because significant differences of economic activity will still exist. Common development possibilities for municipalities, which can be perceived both positively and negatively, were obtained in the second phase of evaluation when conducting cluster analysis.

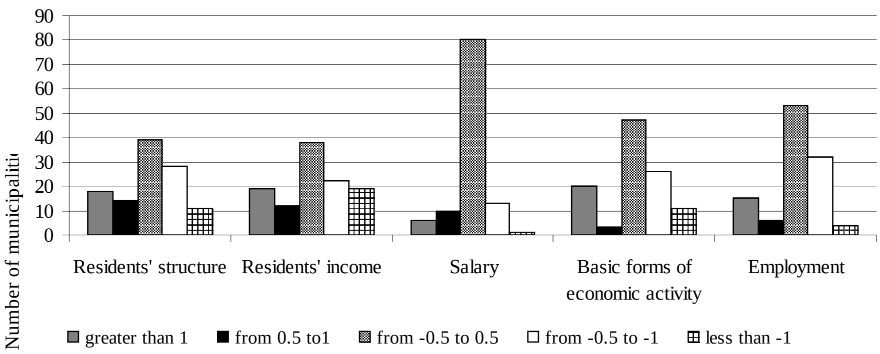

Fig.3. **Estimated number of municipalities in factor value groups as a result of competition scenario**

Positive development tendencies have been identified in 63 municipalities – as a result of cluster analysis they have been included in clusters with particularly favourable situation in one or several expected aspects for instance, high resident income and high wage in 12 municipalities, high population and high number of employees in 15 municipalities, high economic activity in 18 municipalities, higher population and/or depopulation in 13 municipalities. Municipalities, which are grouped in clusters with negative development tendencies, are mainly located in the north of Vidzeme and Sēlija – further from the development centres of national or regional importance, which proves that growth is not transferred to these territories; therefore a set of several measures must be developed to foster the development and growth of these regions.

Scenario of competition in the regional development of Latvia – is based on assumption, that investments in development centres will not create positive changes and growth in other territories in 2020, because development centres will state the socio-economic development of its municipality as more important so fostering the attraction of resources and promotion of competitiveness. Mutual cooperation of territories is not mandatory setting for regulations of national level, so in the case of competition scenario increasing the risk to have weak relationships of cooperation for the interests and needs of municipalities among development centres and surrounding territories.

When comparing the results of all three scenarios, it must be concluded that in the implementation of *competition* scenario, the values of indicators characterising demographic situation in municipalities will show the biggest differences, so creating basis for disbalanced development of municipalities in future. The level of remuneration will equalize in 2020, but economic activity, including offer of working places and the number of employees working in private and public sector, will be significantly different in more than 50% of municipalities. Socio-economic development will be disbalanced in 2020 creating different development basis for municipalities and future potential, which is affirmed by the factor analysis of estimated activity concerning demographic situation and economic activity.

17 municipalities in cluster analysis were grouped in more than three clusters with particularly positive situation; Cesu municipality should be especially pointed out as it is in five of the most positively valued clusters. Other municipalities are development centres of regional importance and Marupe municipality (rural municipality). Other municipalities have favourable situation just in separate areas. Favourable age structure has been estimated for 12 municipalities, high income could be at 3 municipalities, economic activity – 3 municipalities. When considering the total amount of employees in the territory of a particular municipality, employees working in a private sector prevail in 7 municipalities. As a result of competition scenario, 64 municipalities are grouped in clusters with negative development, for instance, clearly low economic activity and small proportion of employees at a private sector could represent the situation in 20 municipalities. Negative age structure, which is characterised by high load of demographic level and the proportion of working age population from the total population, is foreseen in 12 municipalities.

In the result of three scenarios, the most balanced spatial development in 2020 is estimated to be in the case of *status quo* scenario. However, taking into account the views of experts about the current lack of cooperation among municipalities as well as absence of a measure set for certain development and growth transfer, it can be estimated that the most predictable development scenario is the third – *competition* scenario, as a result, NDP motive of *economic breakthrough* and the main goal of regional policy about balanced spatial development will not be achieved. Ts very important to develop a set of measures for transferring the development from development centres of national and regional importance to surrounding territories by stating it as a duty to develop cooperation with municipalities of surrounding regions and not delegate this task to development centres.

CONCLUSIONS

1. The balanced spatial structure and reduction of socio-economic differences in administrative territories in 2020 can be achieved in framework of current regional policy, if growth will be transferred from development centers to other municipalities. In the result of three scenarios, the most balanced spatial development in 2020 is estimated to be in the case of *status quo* scenario, which foresees the investment in development centres maintaining the existing development tendencies.

2. Taking into account the views of experts about the current lack of cooperation among municipalities as well as absence of a measure set for certain development and growth transfer, it can be estimated that the most predictable development scenario is the third – *competition* scenario, as a result, NDP motive of

economic breakthrough and the main goal of regional policy about balanced spatial development will not be achieved.

3. In Latvia, the formation of urban and rural cooperation is delegated to local governments. It could jeopardize achievement of long-term development objectives and performance indicators, especially in the case of limited public investment. Therefore Ministry of Environment Protection and Regional Development must elaborate municipalities' cooperation guidelines, requiring mutual cooperation to ensure economic activities and equal quality of life in both rural and urban areas; as well as require inclusion of the set of measures that would promote cooperation between rural and urban municipalities in development planning strategies in national and regional development centers.

ACKNOWLEDGEMENTS

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THE VALUE OF CULTURAL HERITAGE: THE STATE IN BELARUS AND LATVIA

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Abstract. *It is widely recognised that cultural heritage is increasingly important as a strategic resource for encouraging sustainable economic growth. Traditional cultural expressions such as traditional handicrafts and other expressions of traditional cultures are valuable cultural, social and historical assets, which promote income generation and economic development, particularly in rural areas and at regional level. Moreover, encouraging local cultural expressions contributes to the growth of culture-related economic activities such as revitalising food traditions and producing handicrafts, including artisan or craft foods. Nowadays the relations and collaboration between producers and consumers, so-called co-creation increases significantly. The offer of goods and services is largely determined by consumers' wishes, their degree of awareness and preferences. The aim of the research is to estimate the influence of nationality on attitude to the cultural heritage as well as cultural heritage functionalities in today's conditions. Two surveys of the population were performed – in Belarus (n=66) and in Latvia (n=120). Despite the sample group is not representative, the obtained data and results provide insight into the issues of cultural heritage in today's circumstances through the population views in both countries. The findings show that some similar and some different attitudes and preferences are observed in Belarus and Latvia. All respondents in both countries (Belarus and Latvia) recognised that the cultural heritage as value could be preserved and maintained. They consider that only a small part of the population is sufficiently aware of this value. Regarding the socio-economic value and historical value of cultural heritage, first is higher than second in both countries, but the Latvian respondents ranked the historical value 3.6 times higher than Belarusians. Furthermore, there are popular historical forms (e.g. farmers, 'green' markets) of purchasing gastronomic goods in Latvia. In Belarus preference is given to special departments in the supermarkets.*

Key words: *cultural heritage, value, awareness, rural.*

INTRODUCTION

Taking into account the urgency of regional development and in particular rural development, the importance of finding a new kind of measures and activities, which would encourage sustainable development, is gained. It is widely recognised (Loulanski, 2006; EC, 2014) that the cultural heritage is increasingly important as a strategic resource for encouraging sustainable economic and social potential. This is in line with UNESCO general policy aims: "to give the cultural and natural heritage a function in the life of the community" (UNESCO, 1972).

Traditional cultural expressions such as traditional handicrafts and other creative expressions of traditional cultures are valuable cultural, social and historical assets of the communities and serve as a promoter of income generation and economic development (UNESCO, 2013). Traditional cultural expressions may also serve as a base for new cultural expressions, as they may be a source of inspiration to other creators and innovators, who can adapt them and derive new creations and innovations from them.

The cultural heritage applies to several government policies: cultural, such as those related to regional development, social cohesion, and others, for example, agriculture, maritime tourism, education (Council…, 2014). These policies have a direct or indirect impact on cultural heritage and at the same time cultural heritage offers the potential for the achievements in sectors such as agriculture, for example. Daugstad et al. (2006) emphasize the role of agriculture in the maintaining of cultural heritage.

The scholars (Daugstad et al., 2006) argue that the authentic cultural heritage is local, old, traditional and sustainable, where the globalisation is seen as a threat, which makes everything less local and less authentic.

Moreover, encouraging local cultural expressions contributes to the growth of culture-related economic activities (Facchinetti, 2014). Although, it is outlined (EC, 2014) that the major problem faced by the heritage sector is the progressive disappearance of traditional skills and crafts, which could be renewed.

Primary agricultural production has a decreasing role in rural economy in terms of population, employment and GDP (Moreddu, 2013). Hence, the diversification of farm activities, multifunctionality and pluriactivity become a more significant solution for farms' viability (Bergman et al., 2007; Blad, 2010; Turtoi et al., 2013), especially for semi-subsistence farms (Davidova et al., 2013). The socio-economic vitality of rural areas needs local employment beyond agriculture, such as micro-business, small and medium sized enterprises, and crafts, artisan activities, where cultural and social traditions play a significant role (Dwyer, 2003). Beside traditional rural values, habits, arts and crafts have been revitalised (EC, 2014).

Some of them, which are recommended as a tool for raising income, are revitalising food traditions and the production of artisan or craft foods and handicrafts (UNESCO, 2013). Besides, there is growing interest by consumers in the different kind of fairs and fests, in which crafts and artisan products, inter alia, food, have been offered. Nowadays the relations and collaboration between producers and consumers, so-called co-creation (cocreation) (Hoyer, 2010), increase significantly. The offer of goods and services is largely determined by consumers' wishes, their degree of awareness and preferences.

Previous research studies conducted in Latvia focused on the progress of cultural heritage products as value and the introduction of such products by businesses in Latvia's rural areas (Jeroscenkova L., Kruzmetra M., Rivza B.). During the course of research, a question arose regarding how people in other countries perceive the trend in globalisation expansion and, at the same time, the trend in maintaining and preserving the national identity, as well as what their assessment of the role and availability of cultural heritage are; a research study on the situations in Belarus and Latvia was a response to this question.

Taking into account the abovementioned considerations, **the aim** of the research is stated as follows: to estimate the influence of nationality on attitude to the cultural heritage as well as cultural heritage functionalities in today's conditions. The tasks of the research are: 1) to estimate the similar and distinctive attitudes of awareness, regarding cultural heritage, in Belarus and Latvia; 2) to assess the understandings and value of cultural heritage in both countries.

Especially this activity expanded with initiating the government-funded research project "Rural and Regional Development Processes and Opportunities in the Context of Knowledge Economy" whose one of the key goals is the development of a strategy for smart rural and regional development to obtain an integral vision, including social and economic values of cultural heritage (EKOSOC-LV 5.2.3.).

MATERIALS AND METHODS

Methodology of the research. Globalisation and cultural heritage theories serve as a methodological basis for the present research. One of the leading researchers of globalisation, Manfred Steger, underlines that „The transformation powers of globalisation reach deeply into all dimensions of contemporary social life" (2010). Globalisation is characterised by two trends of change. The first one is the growing flow of goods, services, capital, money and individuals among countries, the trend of equalisation that emerges from the transfer of techniques and technologies from others, which is usually viewed as a positive trend. On the other hand, a number of negative effects of this process are highlighted, especially in the social sphere – the increasing geographical movement of labour force and the formation of ethnically and nationally mixed societies (Reinert E.S.2008; Castells M., 1997). As John Tomlinson writes, „globalization has been associated with the destruction of cultural identities, victims of the accelerating encroachment of a homogenized, westernized, consumer culture" (Tomlinson J., 2003:269)

The principal **materials** used for the research are as follows: 1) different sources of scientific publications, research papers, the EU legislation, and the reports of international and EU institutions; 2) results (data) of surveys in Belarus and Latvia.

The surveys were carried out in the period from November to December 2014 for two groups of respondents: one in Belarus (n=66), and the second in Latvia (n=120). Despite the fact that the sample group is not representative (does not reflect the views of the entire population), the obtained data and results of its analysis provide insight into the cultural issues in today's circumstances through the population's views.

The suitable qualitative and quantitative research **methods** have been used for various solutions in the process of the research: survey, analysis and synthesis; the logical and abstract methods, the constructive method; data grouping and comparing; expert evaluation and etc.

RESULTS AND DISCUSSION

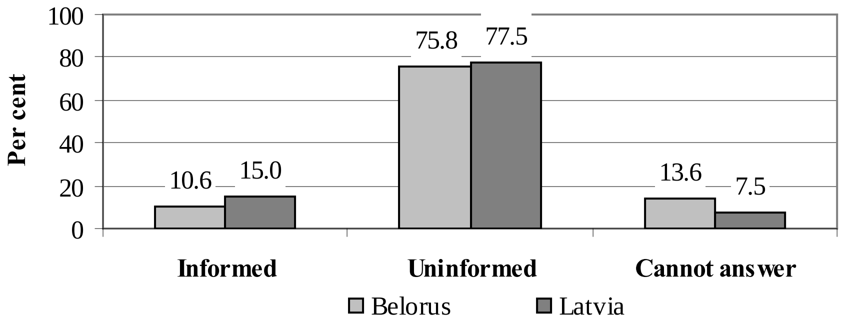
The preconditions for comparing the opinions of residents of several countries are created by the difference in the process of assessing the roles of globalisation and cultural heritage. Different globalization processes operate in different combinations in different regions, with different results. There is no one rural experience of globalization, and no pre-determined outcomes. National, regional and local factors can all intervene to shape impacts and responses. (Developing Europe's..., 2011).

The concept of heritage leads us to a discussion of the continuity between past and present. Heritage provides historical depth and a permanent pattern in a perpetually changing world. Heritage is part of the present, and at the same time holds promises for the future; the problem of the past is a modern one. (Besiere J. 1998) Cultural heritage valuation is based on two main categories – historical values and socio-economic values (Szmelter 2013). Socio-economic values of cultural heritage provide opportunities for small businesses and crafts in rural areas.

1. Similar and different perspectives on cultural heritage as value

All the respondents, both in Belarus and in Latvia, with no exception (100%) regarded their cultural heritage as a value to be maintained and preserved in both the first and in the second country. Yet, they believed that only a small part of residents were informed about this value.

The respondents explained residents' low awareness of their cultural heritage by several reasons: first, the unavailability of information, followed by the poor content of information and the poor setting/design of it. They also pointed to the fact that part of residents had low interest in this phenomenon.



Source: authors' calculations and construction based on the survey data

Figure 1. **Percentage distribution of the respondents' awareness of cultural heritage in Belarus and Latvia, 2014**

The limiting factors of awareness and their percentage distribution are represented in Table 1, which shows the differences in the significance of the factors between the countries. Latvians have higher (nearly 5 times) interest in information than Belarusians and have accented the shortage of information, as well as the too flat and inconspicuous advertising (Table 1).

Table 1

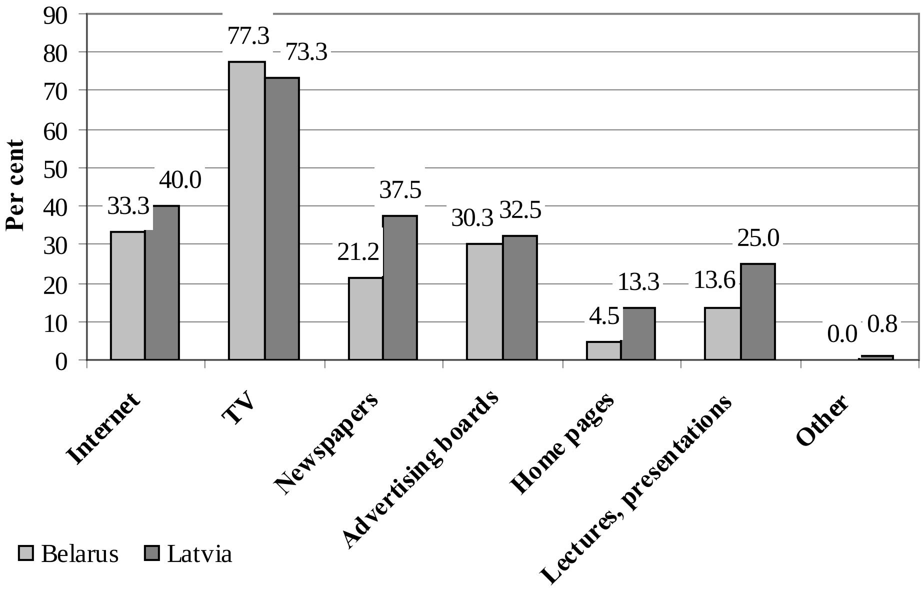
The limiting factors* of awareness and their percentage distribution in Belarus and Latvia, 2014

Country	Limiting factors			
	Shortage of information	Ineffective marketing measures	Too flat and inconspicuous advertising	No interest in information
Belarus	33.3	48.5	7.5	19.7
Latvia	60.8	45.8	25.0	4.2

** – Several answers possible*
Source: authors' calculations based on the survey data

Yet, according to the respondents, most individuals (80.3% in Belarus and 95.8% in Latvia) wished more and detailed information about their cultural heritage.

Under globalisation, the key channels of information are associated with the latest technologies shaping the flow of information and the domain of use of cultural heritage. Figure 2 shows the information sources from which inhabitants receive information on cultural heritage and the importance of the main sources in Belarus and Latvia. The preference was given to TV and the Internet in both countries.



Source: authors' calculations and construction based on the survey results

Figure 2. **Percentage distribution of the main sources of information (several answers possible) on the cultural heritage by popularity in Belarus and Latvia, 2014**

The data obtained in the surveys show that both in Belarus and in Latvia mass media such as the Internet, television shows and websites of cultural organisations serve as important channels for getting new knowledge. However, traditional information channels such as newspapers and billboards have not become less important. And finally, direct contacts with the deliverer of information and knowledge in the form of lectures when questions can be asked and replies can be received have maintained their positions as a significant source of information and new knowledge.

In the result, one can conclude that there was interest in cultural heritage as value both in Belarus and in Latvia. An explicit wish to get more and detailed information on their cultural heritage was observed in both respondent groups. However, the greatest differences were observed in:

– the use of traditional information channels – newspapers, lectures and presentations were more popular in Latvia than in Belarus;
– the activities of getting additional information on the cultural heritage – in Belarus, according to the respondents, the less active population was greater than in Latvia.

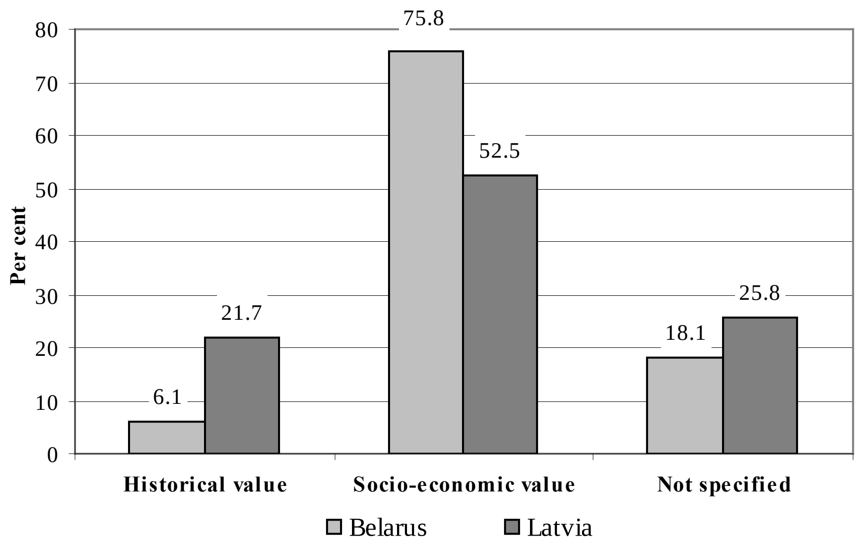
2. Accents of the understanding of cultural heritage values

The most recent research studies express an idea that cultural heritage as value has two aspects. On the one hand, cultural heritage is associated with a nation's efforts to preserve and be aware of its history and to maintain the understanding of belonging to it (landscapes, castles, churches, manor houses, monuments, etc.). On the other hand, in many aspects cultural heritage is important as a socio-economic value (traditional foods, crafts, elements in clothing, etc.) (Szmelter I., 2013).

The socio-economic aspect of cultural values closely relates to the opportunities to acquire such values and, first of all, the gastronomic cultural heritage which the public increasingly focuses on.

The results of the surveys show (Figure 3) that the preference of the socio-economic value of cultural heritage was higher than the historical value in both countries – Belarus and Latvia.

However, the Latvian respondents ranked the historical value 3.6 times higher than the Belarusians.



Source: authors' calculations and construction based on the survey data

Figure 3. **Percentage distribution of the respondents' views on importance of the historical and socio-economic values of cultural heritage in Belarus and Latvia, 2014**

For this reason, there was a wish to get information about shopping places, the specifics of items and services, the production of goods and services and the available assortment. Interest in the production of goods and services prevailed in Belarus (36.4%), whereas every second respondent in Latvia expressed a wish to learn more about the specifics of goods or services (51.7%). Every third respondent (30.3% in Belarus and 30.8% in Latvia) admitted that it was possible to get additional information on the issues they were interested in. However, an explicit wish to get more information (53.0% in Belarus and 41.7% in Latvia) was observed, which might evidence that the information space regarding cultural heritage values was not complete in none of the countries.
Scholars (Tellstrom et al., 2006; Brulotte et al., 2014) argue that the cultivation, preparation, and consumption of food is used to create identity claims of 'cultural heritage' on local, regional, national and international level. The shopping places for gastronomic cultural values presented some differences. Direct producer-consumer contact places such as market places, including "green markets" and shopping on farms were mainly used in Latvia, whereas supermarkets' departments of ecological products were the most popular in Belarus.

Table 2

Percentage distribution of various shopping places for cultural heritage products by popularity in Belarus and Latvia, 2014

Country	Shopping places					
	Specialty shops	Farmers market	Department* in supermarket	Directly from farmers	"Green market"	Other
Belarus	21.2	15.2	25.8	22.7	6.1	0.0
Latvia	22.5	44.2	10.8	35.8	19.5	0.5

* – department of ecological products
Source: authors' calculations and construction based on the survey data

From the perspective of the research aim, it is interesting to compare the explanations for why gastronomic cultural heritage products are not purchased by consumers. The respondents in Belarus explained this situation by the lack of information about why such products were better (50.0%), whereas in Latvia the reason was that such products were expensive and, consequently, many individuals could not afford to buy them (54.2%). Nevertheless, there was a great of proportion of the respondents in both countries (47.0% in Belarus and 67.5% in Latvia) who wanted to recommend their relatives, friends and others to consume cultural heritage products. The information obtained in the surveys indicates that there was the demand for gastronomic cultural heritage products, as the respondents expressed their wish to recommend such values to their relatives, friends and other individuals in general; in this case, there are favourable preconditions for an increase in demand. Demand is always associated with supply, and it usually contributes to business expansion.

In Belarus, such a kind of entrepreneurship mainly takes the form of agro-ecotourism, which involves the Byelorussian national cuisine based on organic foods (Агроэкотуризм ...) and the entry of organic agricultural products into the market (Серая Т.). In contrast, in Latvia the so-called "green markets" and food crafts, in which individuals from small agricultural holdings are engaged, expand; they are not able to sufficiently provide for themselves and their families by producing such agricultural products. Those engaged in such an economic activity expand cooperation for the purpose of marketing their products (Pārtikas amatnieki…). Gastronomic tourism becomes an increasingly important pathway in tourism (Gastronomiskais ..).

So, the demand for gastronomic cultural heritage products might increase, which, in its turn, contributes to the supply of the goods and services demanded, the preservation of national traditions and the territory's identity.

CONCLUSIONS

1. The findings of the research reveal that individuals in both Belarus and Latvia perceive their country's cultural heritage as value. The differences may be observed regarding the most important aspect of cultural heritage or the focus on the current situation. The historical/ideological and socio-economic perspectives have existed simultaneously; the question can only be which perspective should be presently given the priority. One can think that from this perspective, according to the surveys, there are certain differences in the views between the public in Belarus and Latvia. It could be associated with the cultural policy accents of the government as well as some differences in the use of flows of information on cultural heritage and of information channels.

2. The gastronomic cultural heritage is important both in Belarus and in Latvia. The populations of both countries prefer traditional and organic foods. They wish to be more informed particularly about this kind of cultural heritage. The difference lies in the ways gastronomic cultural heritage products are purchased; in Latvia the historical shopping forms are still popular – different markets (e.g. farmers, 'green' markets)/ direct sales, which are affected by the agricultural policy in Latvia that focuses on engaging small agricultural holdings in entrepreneurship.

3. The problems that arose during the course of the present research suggest that more comparative research studies are necessary, which could be carried out within a joint project implemented by Byelorussian and Latvian scientists in order to identify a more profound and scientific perspective on the perception of cultural heritage as value and the ways of preserving, maintaining and using it in both countries and to take over the best practices from the cooperation partner.

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DISTRIBUTION OF KNOWLEDGE-BASED ENTERPRISES IN THE URBAN AND RURAL AREAS OF LATVIA

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Abstract. *Transformation of the Latvian economy towards knowledge-based services and industries is one of the main national development goals. In this study, the authors have studied the main economic sectors and enterprises in knowledge-intensive and technology-intensive industries in Latvia.*
We studied economic sectorial distribution around the different categories of territories, ranging from the largest cities to the rural districts of Latvia. Authors divided the Latvian territorial space in four types: (a) Rural-districts as mainly rural territories that lack even a small urbanised nucleus; (b) Town-districts as hinterland of small and medium-sized urban core; (c) Towns – as separate cores of Town-districts. (d) Cities as nine larger urbanised cores.
In general, we can say that in 2013, 68% of the population of Latvia resided in larger or smaller towns and cities, and only 32% in rural areas. A similar situation was observed with respect to a number of enterprises. We can say that 80% of companies are located in small or large urban areas and only 20% in rural areas. Data analysis leads to conclusion that the higher degree of urbanization, the greater the number of people employed in high-technology manufacturing industries and knowledge intensive services sectors. However, less-knowledge intensive services play an important role in all types of territories. This study has implications for understanding that even small urbanised core in the district play an important role in local economies, because in all four territory types we found different sectorial specialization profile. It is in line with the urban hierarchy and theoretical concepts of territorial specialization.

Key words: *knowledge-intensive services, high-technology, sectors, localization.*

INTRODUCTION

Most of the world's population in urban areas exceeds the rural population. Latvia, in this sense is no exception. According to the data of Central Statistical Bureau of Latvia, this trend has been observed since 1959 and continues to grow every year. At the same time, in previous studies, authors have observed correlations, suggesting that the majority of the Latvian cities and towns demonstrate low number of enterprises, which in most cases occurs within a small local population. In the majority of the Latvian cities and towns a low concentration of business activity has been observed and in most cases it has been observed on a background of small local population. This might be explained by the fact that a small population results not only in limited sales markets, but a possibly limited labour market effect as well. Of all the observed 76 cities and towns, in 50% cases the cities and towns have less than 160 enterprises with less than 33 different economic activities (NACE 2 Rev. Details of Divisions). Strong urban hierarchy and strong inequalities have been observed in all Latvian cities and towns, ranging from larger centres, and with each subsequent level differences get more distinctive [1]. Earlier researches have shown that small enterprises that invest a large part of its profit to research and development tend to be located in an area with most supportive business milieu, and in the vicinity of high-quality business services suppliers. By contrast, large companies can afford to set up their branches in remote areas, due to their greater economic flexibility and ensure their own a support service [2]. In addition, high science-based industry turns out to be more localised than other industries, especially in the European Union. The robust empirically investigation made by S. Vitali, M. Napoletano and G. Fagiolo present evidence that enterprises tend to be located in very urbanised areas due to presence of services and internal market effect [3],[4]. The role of geography and localization in the process of innovation highlights that knowledge flowing from neighbouring regions improves regional growth performance. At the same time knowledge spillovers are geographically bound due to strong distance decay effect, which in the European case expands to more or less a 200 km radius [5].

Thus we forward the **hypothesis** that, knowledge-based manufacturing and service sector companies are unevenly spread within the territory of Latvia and their specialization may depend on the localization belonging to rural or urban territorial type. The **aim** of the research is to assess the distribution and specialization of manufacturing and service sectors in Latvia and to determine the role of knowledge-intensive enterprises in business activity and employment in the different types of territories. The **research tasks** have been formulated as follows:

1. To define the types of territories (from urban to rural) according to territorial administrative division;
2. To determine the manufacturing and services sectors that are widely distributed within each territorial type;
3. To assess the share of enterprises in knowledge-intensive, high technology and medium-high technology sectors in each type of territory;
4. To identify geographical localization of enterprises in knowledge-intensive, high technology and medium-high technology sectors and assess its role in local employment and business activity.

MATERIALS AND METHODS

The empirical research builds on the survey of enterprises around the entire territory of Latvia. In this research, authors analysed data on 40 264 enterprises. Research includes the data obtained from the SIA Lursoft database, created especially for the ECOSOC.LV project 2.5.3. Research was conducted in two stages.

At the first stage, authors defined ten most widespread economic sectors for each type of the territory. This data sample did not include sector of trade (NACE II 45, 46, 47), due to a large number of the enterprises in that sector that might complicate interpretation of the analysis of the services sector. At this stage of research data sample included 17 088 enterprises. Thus, authors found out what economics sectors are characteristic for each type of the territory.

At the second stage we analysed only Knowledge-intensive services (KIS) and High-technology intensive industries (HT) and Medium High-technology intensive (MHT) industries. Data sample included 9408 enterprises distributed throughout the entire territory of Latvia.

The authors aimed to find out the specificities of KIS, HT and MHT sectors in the different types of territories, as well as, to determine their geographic location. We also divided the sectors in two parts. Firstly sectors with the largest number of employees, secondly sectors with the largest number of enterprises in it. The research analyzes the situation in 2013 and the following methods were used for the study purposes: comparative analysis and synthesis, and graphical data analysis.

RESULTS AND DISCUSSION

Due to the huge diversity of the theme scope of knowledge economy authors focused on the two main aspects: geographic distribution of economic activity and location of knowledge-based enterprises.

In this article, authors divided the Latvian territorial space in four types:

a) Rural-districts as mainly rural territories that lack even a small urbanised nucleus;
b) Town-districts as hinterland of small and medium-sized urban core;
c) Towns – as separate cores of Town-districts;
d) Cities as nine larger urbanised cores in some cases excluding Riga as a very special case.

According to the data of the Central Statistical Bureau of Latvia, at the beginning of 2013, population in Latvia accounted for 2 023 825 residents. From them, 51% live in the largest cities and in capital Riga, 17% in the towns, and 32% in rural areas, or in areas outside the cities or towns. Each area is characterized by a certain type of a profile of economic activity. In continuation, authors offer to compare most frequently observed sectors for each type of territories (rural-districts, town-districts, towns, cities). Figure 1 illustrates major sectors of services and industries in rural areas by the number of enterprises and the number of employees.

Figure 1 shows that ten most frequently observed sectors in rural districts belong to NACE II branches (01), (49), (69), which account for 37% of all enterprises in these ten sectors in rural districts. At the same time, the largest number of employees is observed in sectors (1), (49) and (16), which make up the bulk (59%) of ten most frequently observed sectors in rural districts.

In continuation, authors focus attention on the situation in town-districts. Ten most frequently observed sectors in this territory type are illustrated in fig. 2. Despite the fact that the town-district territory is essentially similar to rural areas, it is not a big surprise that the most common sectors are similar in the rural districts, in other words; nine out of ten sectors coincide).

01_Crop and animal production, hunting and related service activities; 02_Forestry and logging; 16_Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; 41_Construction of buildings; 43_Specialised construction activities; 49_Land transport and transport via pipelines; 68_Real estate activities; 69_Legal and accounting activities; 70_Activities of head offices; management consultancy activities; 96_Other personal service activities

Source: the author's construction made in accordance to the data provided by Lursoft Ltd, 2015

Figure 1. **TOP 10 most widespread sectors of economy in Latvian rural districts, number of employees and number of the enterprises in 2013, n = 3721.**

01_Crop and animal production, hunting and related service activities; 02_Forestry and logging; 16_Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; 41_Construction of buildings; 43_Specialised construction activities; 49_Land transport and transport via pipelines; 55_Accommodation; 68_Real estate activities; 69_Legal and accounting activities; 96_Other personal service activities;

Source: the author's construction made in accordance to the data provided by Lursoft Ltd, 2015

Figure 2. **TOP 10 most widespread sectors of economy in Latvian town districts, number of employees and number of the enterprises in 2013, n=4030.**

However, differences can be observed in the internal structure of sectors, by number of companies and employees. For instance, 62% of ten most frequently observed sectors take the enterprises in sectors (01), (02), (16). And the largest number of employees is observed in the same sectors (01), (02) and (16), which make up the bulk (63%) of ten most frequently observed sectors in town-districts. Two territory types observed previously are attributable to rural areas, two next examples describe territories of towns and cities. Figure 3 shows ten most frequently observed companies in towns, in breakdown by sector.

As it showed in fig. 3 sectors (43), (49), (68) in towns account for 1347 enterprises or 39% of ten most frequently observed sectors in this territory type. The largest number of employees is observed in the sectors (16), (49) and (86), which make up a significant part (45%) of employment in ten most frequently observed sectors in towns. Next territory type is the cities, showed in fig.4.

As it showed in figure 4, most frequently observed enterprises belong to sectors (43), (49), (68), (69) which make up the bulk (57%) of ten most frequently observed sectors in cities. In turn the largest number of employees was observed in sectors (49), (56), (68) which take up 51% of the number of employees in ten industries prevalent in the cities.

02_Forestry and logging; 16_Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; 41_Construction of buildings; 43_Specialised construction activities; 49_Land transport and transport via pipelines; 56_Food and beverage service activities; 68_Real estate activities; 69_Legal and accounting activities; 86_Human health activities; 96_Other personal service activities;

Source: the author's construction made in accordance to the data provided by Lursoft Ltd, 2015

Figure 3. **TOP 10 most widespread sectors of economy in Latvian towns, number of employees and number of enterprises in 2013, n=3382.**

41_Construction of buildings; 43_Specialised construction activities; 49_Land transport and transport via pipelines; 56_Food and beverage service activities; 62_Computer programming, consultancy and related activities; 68_Real estate activities; 69_Legal and accounting activities; 70_Activities of head offices; management consultancy activities; 71_Architectural and engineering activities; technical testing and analysis; 96_Other personal service activities.

Source: the author's construction made in accordance to the data provided by Lursoft Ltd, 2015

Figure 4. **TOP 10 most widespread sectors of economy in Latvian cities, number of employees and number of enterprises in 2013, n=5955.**

The specific set of sectors has been identified for each type of territory, and further the authors will focus on analysis of knowledge-based sectors, preserving the previous territorial typology.

Rural districts. Looking at the manufacturing and service companies the percentage breakdown by technological intensity and knowledge intensity in rural districts, the majority of workers in this territory type running in Less Knowledge-intensive services (60%) and Low-technology industries (10%). However, 27% of employees in rural-districts work in KIS, while 1.1% of employees work in HT and MHT industries.

The largest number of employees in KIS in rural-districts work in the following sectors: Air transport (NACE II, 51), Activities of head offices; management consultancy activities (NACE 70 II) and Gambling and getting activities (NACE II 92). Here it is important to highlight the fact that most of these services are concentrated in regions located in peri-urban area of Riga, (percentage according location: Adazi (9%), Babite (9%), Garkalne (9%) and Marupe (23%) districts). The largest number of employees in HT and MHT enterprises in rural districts, work in such sectors as Manufacture of chemicals and chemical products (NACE II, 20); Manufacture of machinery and equipment n.e.c. (NACE 28 II) and Manufacture of motor vehicles, trailers and semi-trailers (II NACE 29). Unlike the services industries, manufacturing sector enterprises with a large number of employees are located not only around Riga, but also in remote areas like Amata and Rucava districts. The authors would like to note that knowledge intensive and technological intensive sectors, which employ a large number of people, differ from the sectors with a large number of enterprises (but not employees). For example, in rural district KIS sector has the largest number of enterprises in the following sectors: Computer programming, consultancy and related activities (NACE 62 II), Legal and accounting activities (II NACE 69), Activities of head offices; management consultancy activities (II NACE 70), Other professional, scientific and technical activities (NACE 74 II) and Security and investigation activities (II NACE 80). All these companies are located in peri-urban area of Riga (Adazi, Babite, Garkalne, Marupe, Stopini districts). In the case of HT and MHT manufacturing companies, the largest number of companies belongs to the following sectors: Manufacture of chemicals and chemical products (NACE 20 II), Manufacture of computer, electronic and optical products (II NACE 26), Manufacture of machinery and equipment n.e.c. (II NACE 28). The total number of people employed in KIS, HT and MHT sectors in rural districts accounts for 8293 employees.

Town-Districts. The largest share of employees work in Less Knowledge-intensive services (57%) and in Low-technology industries (28%). 9% of employees work in KIS, while 0.8% of employees work in HT and MHT industries. The bulk of the number employees in KIS works in such sectors as Security and investigation activities (NACE II, 80), Human health activities (NACE 86 II) and Residential care activities (II NACE 87). The majority of these service suppliers are located remotely from Riga in Aizpute, Akniste, Cesis, Ligatne districts, except for companies that are located in Salaspils district. The largest number of people employed in HT and MHT sector belongs to such sectors as Manufacture of chemicals and chemical products (NACE II, 20); Manufacture of computer, electronic and optical products (NACE 26 II), Manufacture of machinery and equipment n.e.c.(II NACE 28) and Manufacture of other transport equipment (II NACE 30). The main employers in these sectors, in town-district territory type are located in Grobina, Saldus, Talsi and Kekava districts. Analysing the number of enterprises by sector we found that the greatest number of the enterprises in KIS sectors belongs to the following sectors: Legal and accounting activities (NACE II 69), Activities of head offices; management consultancy activities (NACE II 70), Architectural and engineering activities; technical testing and analysis (NACE II 71), Other professional, scientific and technical activities (NACE II 74) and Sports activities and amusement and recreation activities (NACE II 93). The majority of the enterprises in these sectors are located in close proximity to Riga, in Kekava, Olaine, Salaspils, Sigulda, Limbazi districts. In case of HT and MHT sectors, we found a large number of manufacturing enterprises operating in such sectors as Manufacture of chemicals and chemical products (NACE II 20), Manufacture of machinery and equipment n.e.c (NACE II 28), and Manufacture of other transport equipment (NACE II 30). The total number of people employed in KIS, HT and MHT sectors in town districts accounts for 39839 employees.

Towns. The largest share of employees work in Less Knowledge-intensive services (51%) and in Low-technology industries (20%). 18% of employees work in KIS, while 4% of employees work in HT and MHT industries, which is significantly more than in rural or town districts. The largest number of people employed in KIS sectors in towns works in such sectors as Employment activities (NACE II; 78) and Human health… (II NACE 86). The majority of these service supliers are located remotely from Riga in Balvi, Madona, Ogre, Strenci, Tukums. The largest number of people employed HT and MHT sectors works in Manufacture of chemicals and…(NACE II 20), Manufacture of basic pharmaceutical products and pharmaceutical preparations (II NACE 21), Manufacture of computer…(NACE II, 26); Manufacture of electrical equipment (NACE II 27), Manufacture of machinery …(II NACE 28). Major employers of these sectors are located in Livani, Ogre, Salaspils and Olaine. Analysing the sectors by number of enterprises, we found, that the largest number of companies in KIS sector, belong to the followings ectors: Computer programming…(NACE 62 II), Legal and accounting…(II NACE 69), Architectural and engineering …(NACE 71 II), Other professional, scientific…

(II NACE 74) and Human health…(II NACE 86). Most of these industries are located in Balozi, Cesis, Ogre, Salaspils, Sigulda. In the case of HT and MHT manufacturing enterprises, the largest number of enterprises belong to the following sectors: Manufacture of chemicals …(NACE 20 II), Manufacture of computer…(II NACE 26), Manufacture of machinery…(II NACE 28) and are located in Cesis Lielvarde Ogre, Olaine. The total number of people employed in KIS, HT and MHT sectors in town districts accounts for 61 660 employees.
Cities. The largest share of employees work in Less Knowledge-intensive services (53%) and in Low-technology industries (9%). 31% of employees work in KIS, while 3% of employees work in HT and MHT industries. KIS sectors that provide the highest number of jobs are Telecommunications (NACE 61 II), Public administration and defence; compulsory social security (II NACE 84) and Human health… (II NACE 86). The largest number of companies in this sector are located in Daugavpils, Liepaja, Rezekne, Riga. Enterprises of the HT and MHT sectors, employing a large number of employees, work in such sectors as Manufacture of chemicals…(NACE 20 II), Manufacture of basic pharmaceutical…(II NACE 21), Manufacture of electrical…(NACE 27 II), Manufacture of other transport…(II NACE 30). The largest number of enterprises registered in KIS sectors belong to the following sectors: Computer programming…(NACE 62 II), Legal and accounting…(II NACE 69), Activities of head offices…(II NACE 70), Other professional, scientific…(NACE 74 II), Human health… (II NACE 86). These sectors are most commonly observed in Riga and Daugavpils. HT and MHT production facilities most often are seen in sectors like Manufacture of chemicals… (NACE 20 II), Manufacture of electrical…(II NACE 27) and Manufacture of machinery…(II NACE 28). The majority of enterprises of this sectors are located in Daugavpils, Liepaja and Riga.

CONCLUSIONS

1. In this research, the territory was divided according to the principles of administrative division. Nevertheless, it created a situation when the formal rural districts located close to the cities in own economic specialization are more resembled in the cities, than rural districts located remotely. Thus, a distance factor, especially in suburbs should be emphasized in further research.

2. We studied four types of territories and conclude that economic specialization of the rural districts and the town districts demonstrates insignificant differences. Nevertheless, distinctions are found in internal structure of sectors by number of the enterprises and employees. The sectorial profile in the town differs from the town-district and rural-district, and also of the cities. This type of area should be especially studied in further research. Functionally diverse economic profiles are observed only in the cities. The number of employees in each type of territory, increases within the total number of the population. At the same time, the number of employees in the different sector enterprises varies between 2-23 per one enterprise. It leads to conclude that small enterprises are extended across the entire territory of Latvia.

3. The share of KIS, MHT and HT in sectorial profile of different territory types enlarge within territory urbanization degree increasing. At the same time, low-technologies and less knowledge intensive sectors make up the bulk of economy in all territory types. KIS is more widespread, than HT and MHT. Besides, variance of the services offered above than variance of the industries.

4. Enterprises with the largest number of employees in KIS are most often located to the vicinity of Riga, rarely in Vidzeme and Kurzeme regions. However, they are located in larger cities of Kurzeme and Latgale and also in Riga. A large number of companies of KIS sectors are localized close to Riga, and less in Vidzeme. At the same time, enterprises in High-technology and Medium High-technology sectors, with a large number of employees are localized not only near Riga, but also in Kurzeme and Vidzeme regions, evenly in all types of territory.

ACKNOWLEDGEMENTS

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FACTORS INFLUENCING E-COMMERCE DEVELOPMENT IN BALTIC RURAL AREAS

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Abstract: *In this article author observing key factors influencing development of Internet and electronic commerce in Baltic countries. Author analysing statistic data for Latvia, Estonia and Lithuania and comparing different processes in politic, economic and social life of those countries during the last 24 years. Development of telecommunication infrastructure, information technologies and electro technic created absolutely new business environment where business development has a different rules and possibilities. New possibilities and challenges have a different usage in different counties. Even small time periods in development of telecommunication infrastructure can influence number of users of Internet and later on e-commerce as well. Lever of welfare in any country influencing usage of technologies and habits of population and adaptation to new business environment. Than better is economical situation in country than more active population and business environment are in new virtual environment. One of conclusions after analyse of statistic and author researches done in last 5 years in Baltic business area is that general level of education and specially level of digital literacy between different groups of population have a significant influence to usage of e-commerce. Than more countries involving in digital literacy of population and stimulating enterprises to adopt new knowledge and technologies that faster development of e-commerce in public and commercial areas. Governmental activities in development of electronic environment are very important not just to develop legislation, but create electronic services for citizens and business needs to intensify all processes and minimise administrative obstacles. Unfortunately as showing research in small and medium regional enterprises sector, SME are not ready to start business in virtual environment and to use all benefits of new environment. Main reasons are lack of special knowledge about possibilities in new environment, lack of free finances to start e-commerce activities and lack of specialists. From author point of view solution for this problem could be to intensify activities of NGO and local authorities to organize education on possibilities of business development in virtual environment to continue develop e-services for citizens and business.*

Key words: *e-commerce, technologic infrastructure, level of welfare, digital literacy.*

INTRODUCTION

Since the beginning of Internet era, starting in 1969 with *ARPANet* project (*Advanced Research Projects Agency, USA)* Internet and all virtual world benefits are becoming more important in our personal and business life. Activities in a virtual world became day-by-day activities and we do not imagine our life without communication using different Internet tools and electronic devices. Starting from the beginning of 90's the world got to know a new term- electronic commerce.

In 1995 deals in electronic environments reached 159 million USD dollars but in 1998 amount of e-commerce exceeded $ 43 billion. [1] Rapid growth of business activities in the virtual environment exceeded all forecasts and are still developing and growing. The digital revolution crossed borders of countries and became Global, giving to entrepreneurs and customers a totally new environment, roles and tools for communication and exchange of goods and services.

New business environment – New Ecosystem

E-commerce transferring global access to Internet to the level based on main business processes of exchange goods and services, improving those processes to more efficient and more profitable. It is giving enterprises new possibilities, challenges and way for further development on wider market. E-commerce benefits like continuous operation created new terms in our business language – work 24/7/365. Immediate reaction form market and bilateral communication increasing more and more temps of business development. Global auditory and selected target customers groups giving enterprises much more competiveness then

traditional ways of doing business. Personalisation and customisation permits achieving potential customer needs and preferences. All of these and other benefits of the new business ecosystem generating the main one- profitability, target of any business activity. In last 10 years more new services were launched that in all previous century. This new ecosystem developing every second and it is complicated to make prognosis even for next five years development. Human race and business are turning to the virtual ecosystem and there is no way to stop it unless we stop progress itself.
E-commerce, but wide term- e-business totally changed traditional way of doing business but actually everything is quite simple. D. Shaffey describe e-commerce a simple way – "as all electronically mediated transactions between an organization and any third party it deals with." [2]

Basic factors influencing development of e-commerce

Internet and e-commerce in Baltic States developed relatively late, just in the middle of 90's. It was related with development of telecommunication infrastructure. Estonia, Latvia and Lithuania started to develop their own International telecommunication connections to the Global Internet and digitalization of local telecommunication infrastructure. Internet in Latvia and other Baltic Countries has developed in several phases and progress was driven by various technical, economic, political and public factors. In the middle of 90's, immediately after privatisation process of telecommunication companies started a rapid development and modernisation of there telecommunication networks- the base for development of Internet and e-commerce. Direct connections to Global Internet and good level of technical specialists gave many possibilities to use benefits of Internet and e-commerce to enterprises and private persons.
Analysing development of Internet in Baltic countries author concludes that there exists some basic factors for e-commerce development.
In all three Baltic countries modernization of telecommunication network started with 2 years difference- in Estonia in 1992, In Latvia in 1994 but in Lithuania in 1996. It influenced number of Internet users and penetration in every country. [3]

Table 1

E-commerce development factors

Factor/Country	Latvia(LV)	Estonia (EE)	Lithuania (LT)	Data source
Fixed broadband penetration (subscriptions as % of population) 2013	25	28	27	[4]
Fixed broadband coverage %, 2013 (total/rural)	93/43	87/87	96/92	[4]
Mobile broadband penetration – all active users %, 2014	62	90	48	[4]
Internet users% of population, 2014	75,2	83,3	72	[7]
Individuals ordering goods or services online % of all individuals aged 16-74 , 2014	34	49	26	[4]
Individuals interacting online with public authorities, 2014, % of all individuals aged 16-74, 2014	53,5	50,7	41,5	[4]
GDP per capita by years, USD $ (1995/2000/2013)	2107/3308/15375	3036/4070/18783	2178/3267/15538	[4]
Number of Internet users between seniors, % of seniors, 2014	42	55	35	[7]

Development of telecommunication infrastructure even with 2 years difference influenced Internet usage but not significantly. Two other important factors the level of welfare and level of digital literacy of population are important giving the possibility to use benefits of the new virtual business environment. To increase level of digital literacy of the population, especially for the generation above 50 and seniors all three countries organised several government, NGO and commercial organisations non-profit projects to give the possibility for individuals without computer skills to learn basic needs to use the Internet and e-commerce benefits. Public Internet access points especially in rural areas positively influenced Internet and e-commerce usage.

Access to the Internet and increasing welfare of population gave the possibility to develop different type of electronic services and the first big section of e-services started within develop banks and financial organisations giving them possibility to save a large ammount of expences making the business more profitable.

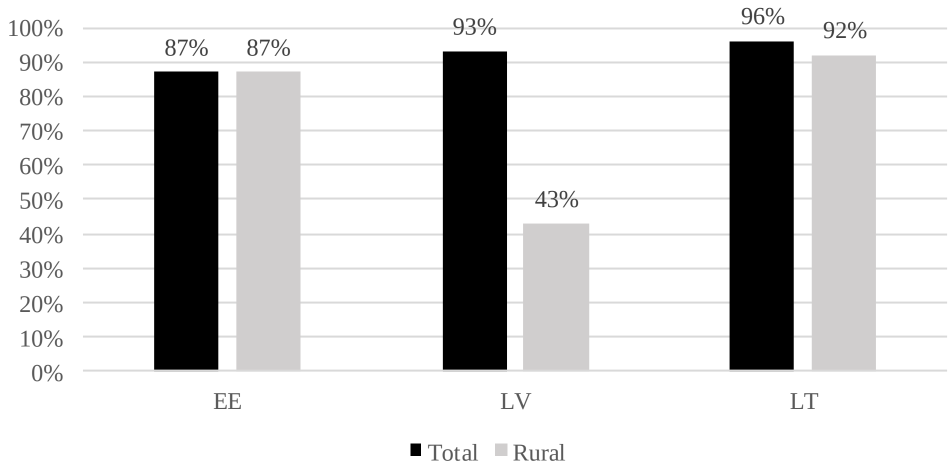

Figure 1. **Fixed broadband coverage in Baltic, 2013 [3]**

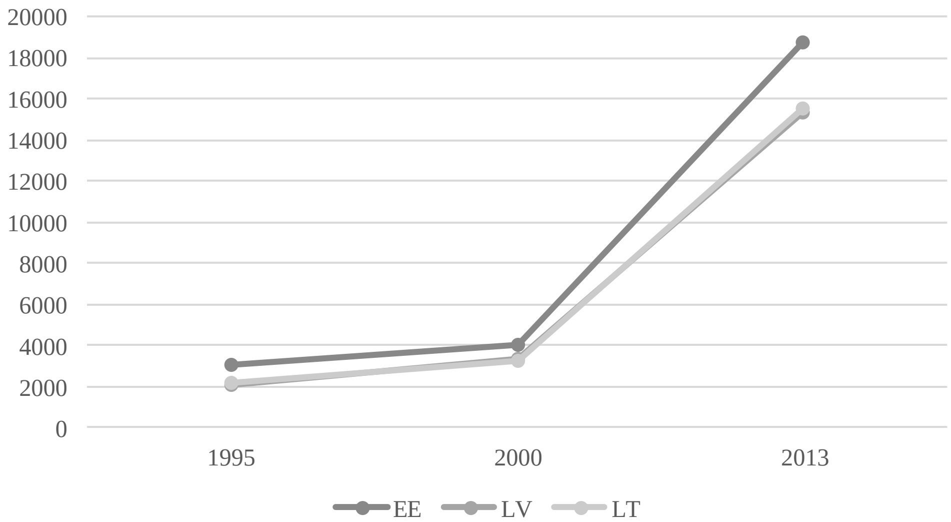

Figure 2. **GDP per capita in Baltic, USD, 2014 [4]**

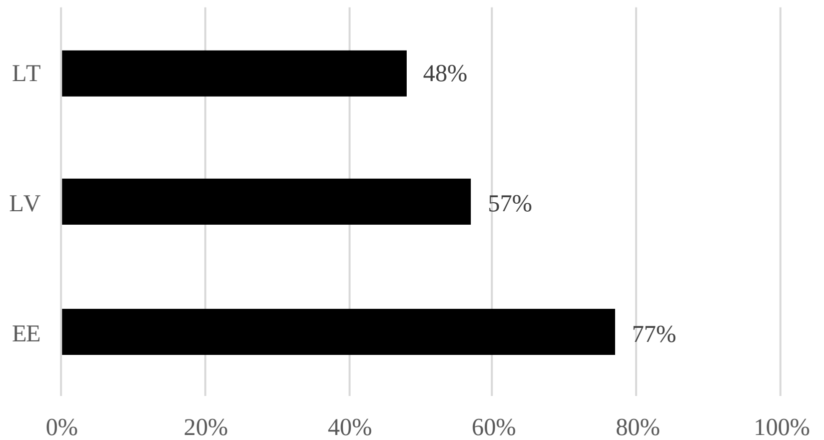

Figure 3. **Online banking penetration in Baltic, 2014, % of all individuals aged 16-74 [5]**

Development of public and commercial electronic services gave the possibility for further e-commerce content development and then more services were provided to the market that encouraged e-commerce growth and usage.

Accessibility to Internet is a main factor for companies to start any activities with in e-commerce even development of company web page. Starting from the 1994, first independent access to Global network Latvia achieve 75, 2% of Internet users, in Estonia it is higher 83% but in Lithuania – 72%. Wealth is growing and electronic devices and Internet access becoming more and more accessible for any inhabitant wherever he/she lives and rural areas are no longer reasons not to have and Internet connection.

Legislation in all Baltic countries is oriented on new technologies and e-services development and governments and local municipalities are investing in financial and human resources for development of infrastructure and e-services for enterprises and all population.

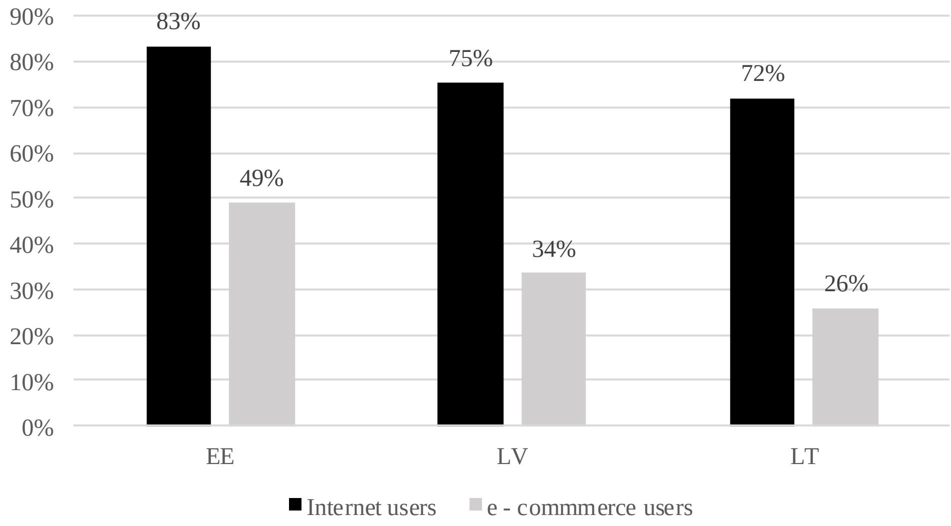

Figure 4. **Internet and e-commerce users in Baltic, 2014, % of all individuals aged 16-74 [6][8]**

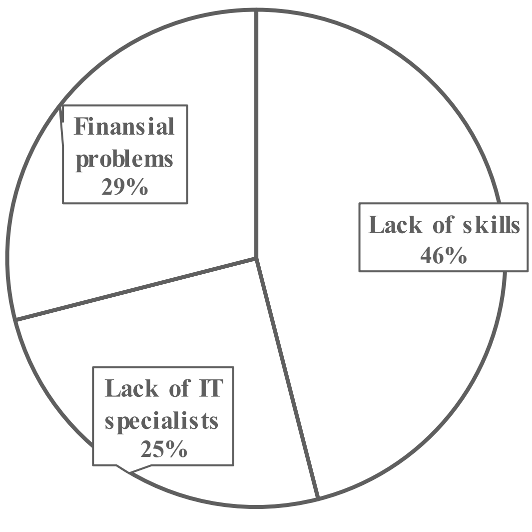

Figure 5. **Reasons for disuse of e-commerce in rural enterprises in Latvia, 2014 [10]**

RESULTS AND DISCUSSION

Cities and large enterprises have solved all problems regarding successful usage of e-commerce tools. Potential customers are ready to use offered services and serious e-commerce era already started for enterprises specialised to e-services. A different situation is in rural are and especially in small and medium enterprises located in rural areas. From results of research done in end of 2014, 420 respondents were electronically interviewed in Latvian rural areas where the situation was different.

68% of respondents consider that local companies are not active in e-commerce and not using new electronic environment possibilities for business development. SME are not visible in Internet and are not using Internet marketing and e-commerce. 54% of respondents are sure that local companies can find a way for development using e-commerce tools and just 12 % of all respondents have opinion that local rural companies have not any possibility and it is not necessary to develop any business activities in Internet environment. The goal of telephone interviews with management of 20 enterprises done in end of 2014 the goal was to find the reasons for such low usage of e-commerce for business development.

The main reason low usage of e-commerce in business development is lack of knowledge for management (46% of respondents) and second one was – lack of specialists who can give vision how to use e-commerce tools for business development, not just to sell products and services. [9]

CONCLUSIONS

Internet and e-commerce development in any country are influenced by 4 main factors:

- Development of infrastructure, access to network, technologies, local access, public Internet points,
- Level of general education and digital literacy between all groups of population,
- Level of economic development, welfare and prices for access and electronic devices,
- Governance and legislation, public services development [11]

If the main factors effecting positive development and influencing e-commerce development and usage, other existing additional factors, mainly based on education factor influencing trend of development in negative way. It is a lack of e-commerce and e-marketing skills for management of small and medium enterprises and a lack of IT specialists in rural areas.

The main solution to improve this situation is to continue all government and NGO activities especially in rural areas for education of population about e-commerce benefits, organization of special courses for management of small and medium enterprises about possibilities to use e-commerce tools for business development and communication with existing and potential customers.

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SAFETY MANAGEMENT REGARDING AGRICULTURAL MACHINERY

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Abstract. *Machinery accidents remain common in agriculture, and in Finland the share of machinery accidents of all farm work accidents has risen in the last years. All Finnish farmers are covered by mandatory accident insurance (Finnish acronym: Mata insurance), administered by the Finnish Farmers' Social Insurance Institution. In international perspecive, the Mata register of documented accidents provides specified information about farm accidents which is not available in many countries. Our "Koneturva" ("machine safety") project 2014-2016 focuses on risk assessment and safe use of agricultural machinery. The project includes: 1) survey and analysis of the machinery accident cases over the years 2004-2014 from the Mata insurance, totally 11 300 accidents. 2) assessment of the safety aspects of user's manuals (handbooks) of some machinery types found to be the most dangerous ones according to the Mata accident data, 3) collecting of experiences of machinery safety risks and usability by inquiries to farmers, the occupational safety authority, and representatives of machinery trade and manufacturers, 4) compiling the results of the project parts 1)-3) into a new machinery safety guidebook, intended for machinery manufacturers and users.*

The project aims to help machinery manufacturers integrate safety features and functions into machinery design as part of machine usability. It is known that farmers tend to by-pass safety features that they feel cumbersome rendering them ineffective and thus compromising safety. Well designed safety features are crucial especially for new agricultural machinery with high level of automation. Finally, we aim to describe machinery safety management principles, describe the overall risk level in machinery use, and provide guidance for machine manufacturers and users that can help them identify, assess and monitor risks related to agricultural machinery.

The project now has results of part 1), the survey of documented accidents. Examples of findings: The estimated cost of benefit payments for serious accidents is about 8 million Euros per year, and machinery cause the majority of serious accidents. On average, one machine accident causes 33 lost workdays and a compensation to the casualty from the insurance of 3800 euros. Farm machinery types causing the most accidents are tractors, trailers, combines, front loaders and other loaders, drills for fertilizer and seed, ploughs, harrows, balers and choppers. The clearly most common situation where accidents occur is not during actual operation of the machines, but during service and repair of the machines – a third of all machinery accidents. Of these, a common accident type is persons being crushed under falling machines and machine parts during repair work. 33% of the farmers are women, but only 8.6% of the machinery accidents have occurred to women. This is probably mainly because women work less with machines than men.

Key words: *Agriculture, machinery safety, machinery accidents, safety management.*

EVIDENCE BASE ON THE IMPACT OF INNOVATION PARTNERSHIP

INNOVATION EMERGES FROM PARTNERSHIP

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Abstract. *'Transfer of Technology' is out, 'Partnership' is in, when it comes to programmes for stimulating innovations in agriculture and beyond. New practices are no longer seen as the result of research findings that found their way to end users, thanks to the efforts of extension agents or advisors. Farmers, researchers, intermediate actors, and also other stakeholders such as policy makers, funding agencies, actors in the value chain and civil society groups are supposed to be partners involved in processes of co-creation that lead to innovations that are relevant for all.*

Can it really work? How can we know it works? In production or trade you can keep the producer or supplier accountable for what he promises to deliver. But how do you value the contribution of each individual partner for what has been created together, without knowing beforehand what this result will be?

My statement is that it takes a mind shift to understand what partnership entails, both from the partners themselves and the enabling community that creates the conditions in which partnerships can flourish.

The Dutch agricultural system has shown an impressive growth in the decades after the Second World War. Knowledge as played a pivotal role in this development, making the Dutch farmers the most productive entrepreneurs in agriculture worldwide. After the privatisation of the public extension service in 1990 the good relationships of the partners in the system became seriously disturbed. While working at the knowledge department of the Ministry of Agriculture in those days, I made a PhD study on the changing role of government in the agricultural knowledge system. My conclusion was that networks, which had been crucial in the old system, were broken up in the new era of neo-liberal market relationships, with negative effects.

It appeared helpful to look at human systems as living organisms that can be more or less healthy. With this approach I engaged in applied research projects on networks for innovations at farm level. We found out that assisting networks of farmers and other stakeholders require different tools and skills than was usual in project management. Also monitoring and evaluation should be done differently.

In this presentation I would like to take you along several of these experiences, which illustrate a theoretical framework for working in partnerships. The good news is that effective networkers have always applied its principles, without which they would not have had results. What is needed however is recognition of their importance, and adaptations in the structure for management, funding and M&E for creating space to do what is necessary.

Key words: *innovation, partnership, farm advisory.*

FARM ADVISORY SERVICE IN POLAND IN LIGHT OF LEGAL REGULATIONS

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Abstract. *The paper presents process of farm advisory system creation (FAS) in European Union Member States, basing on report prepared for the Parliament and European Council. The aim of the paper is to present development of forms and methods of farm advisory service in Poland on the background of legal changes in the state and in other EU Member States. The authors concluded that agricultural farm advisory service was responsible for adjustment processes of rural areas and agriculture to the requirements of the competitive economy in the European Union. At the national level, it created the need to develop a new perspective on the place and role of agricultural farm advisory service.*

Key words: *advisory system, Common Agricultural Policy, farm advisory service, rural areas development.*

INTRODUCTION

Farm advisory service has been of support for farmers for years in the difficult process of administration and management of agricultural holdings. Farm advisory service services influence the human factor in agriculture, giving rise to innovative approaches, which foster the implementation of technological progress. In the light of the new paradigm of farm advisory service, there is a need to do away with the traditional functioning of advisory institutions and to develop new rules, which will be adequate to the changing requirements of the Common Agricultural Policy.

Farm advisory service supports farmers in the process of management of their agricultural farms. Advisory has influence on creation and shape of human factor in agriculture, making innovative activities which are very helpful in introduction of technological progress. At present there may be observed new way of thinking about farm advisory service in all European Union Member States. New rules about advisory service functioning must be worked out which will be adequate to still changing requirements of Common Agricultural Policy [Mickiewicz A., Mickiewicz B., Wawrzyniak, 2014].

Member States have the obligation to establish a system for advising farmers on land and farm management, referred to hereinafter as the Farm Advisory System (FAS). The FAS is a major component of the 2003 Common Agricultural Policy (CAP) reform and had to be introduced by 2007. The objective of the FAS is to help farmers to become more aware of material flows and of on-farm processes relating to the environment, food safety and animal health and welfare. It was introduced at the same time as the cross compliance system, under which CAP support is paid in full only if farmers meet certain requirements relating to the environment, food safety, animal health and animal welfare. There are two rural development policy measures designed to help Member States set up farm advisory services and to help farmers use them. The FAS is indeed primarily a tool to help farmers fulfil those requirements and thus avoid financial penalties under cross compliance.

Under Article 12(4) of Council Regulation EC) No 73/2009, the Commission must send the Council a report on the application of the FAS – accompanied, if necessary, by appropriate proposals. That is the purpose of the present report – to inform the European Parliament and the Council on the state of implementation of the FAS and to propose possible improvements. It is largely based on information received from the Member States in response to a questionnaire and on an evaluation study carried out for the Commission. The FAS was also discussed extensively with the Member States at five FAS workshops organised by the Commission in 2006-2010. These discussions covered the content, structures, methods and tools for national advisory services [Oskam, Meester, Silvis, 2010].

The aim of the paper is to present development of forms and methods of farm advisory service in Poland on the background of legal changes in the state and in other EU Member States. The materials and data were taken from internal regulations of farm advisory service centers in Poland as well as from the Ministry of Agriculture and Rural Development. The studies were made in January 2014.

RESULTS OF STUDIES

Legal framework

Each Member State is legally obliged to set up a national FAS offering advice to farmers. The FAS must cover at least the statutory management requirements and the 'good agricultural and environmental condition' (GAEC) referred to in Articles 4 to 6 of Council Regulation (EC) No 73/2009. However, the field of advice is not limited to cross-compliance standards: Member States may decide to include other issues. Each national FAS may be run by one or more designated authorities or by private bodies. Since the 2008 CAP Health Check, each Member State is free to decide (on the basis of objective criteria) which categories of farmers will have priority access to the FAS, without any further criteria being laid down at EU level.

Farmers use the FAS on a voluntary basis and remain responsible for acting on the advice they receive. In this respect the FAS does not in any way affect their obligation and responsibility to meet the legal requirements. However, the EU legal framework acknowledges that farmers who ask for advice are more likely to be aware of how to fulfil the legal requirements. When selecting farms for inspection, therefore, Member States may choose to consider these farmers as presenting a lower risk.

Raising farmers' awareness of EU legal requirements is the main goal of the FAS. Advice must therefore be clearly distinguished from checks carried out in the framework of cross compliance or to ensure compliance with the sectoral legislation. In this connection, Member States must ensure that the FAS operators do not disclose personal or individual information, or data they obtain in the course of their advisory activity, to persons other than the farmer managing the holding concerned.

The only exception to this rule is if FAS operators discover some irregularity or infringement which is covered by an obligation laid down in EU or national law to inform a public authority, in particular in the case of criminal offences.

POLISH LEGISLATION IN THE SCOPE OF ESTABLISHING THE FARM ADVISORY SYSTEMS

In Poland, legal regulations concerning farm advisory service had been based on the lower legislation acts (regulations) until 2005. The lack of statutory regulations resulted in the uncertainty of advisors regarding the way of financing the centres or the cooperation with other institutions. Since 1 January 2005, the agricultural advisory units have been operating under the act from 22 October 2004 on the agricultural advisory units (Act on Advisory Units, 2004). Reorganization of these units consisted particularly in fulfilling the statutory obligation to organize 16 regional Agricultural Advisory Centres (pol. Osrodek Doradztwa Rolniczego - ODR) as well as in establishing the Central Agricultural Advisory service (pol. Centrum Doradztwa Rolniczego - CDR). The ODR ceased to function as the budget entities and became national organizational units with legal personality.

The main purpose of farm advisory service is to grant support to farmers and other rural inhabitants, who face a problematic situation. The aim is achieved by presenting them the current situation with its conditions, preparing them to recognize the situation, assisting in problems solving and in making their own decisions. The main tasks of advisory units involve economics, organization and management of the agricultural holding, market organization, marketing, financial aspects of the market, insurance, pension and old age retirement as well as a number of other issues. The scope of these issues is enormously wide and involves numerous aspects of agricultural holdings functioning from the typically agricultural activity and its combination with non-agricultural activities to the wide range of training and educational issues. The activities codified in the act on the agricultural advisory units were divided into the tasks performed free of charge (obligatory) and the commissioned ones (facultative), being a kind of service for which one should pay. The obligatory tasks of the Agricultural Advisory Centre involve the following issues.

CONCLUSIONS

In the light of the evaluation set out in this report, the Commission considers that the FAS is an essential tool for a successful implementation of the CAP. Farmers are supported in their efforts to comply with the EU's legal requirements relating to the environment, food safety and animal health and welfare. By assisting them with these 'cross-compliance' requirements, the FAS helps farmers avoid losing CAP payments. A farmer receiving advice is more likely to understand his cross-compliance obligations, and will thus more readily comply with them.

Table 1

Farm advisory services rendered by the ODR

1. Conducting trainings for farmers and other rural inhabitants in the scope of:	1. Other tasks of the farm advisory service centres
2. Applying modern agro-technical, farming and agri-food processing methods	2. Conducting information activities supporting the development of agricultural production
3. Solving technological and organizational as well as economic problems of agricultural holdings	3. Conducting activities aiming at improving professional qualifications of farmers and other rural inhabitants
4. Accounting in agricultural holdings	4. Providing help to farmers and other rural inhabitants in the scope of preparing documentation required to obtain the aid
5. Organic agriculture	5. Conducting market analysis of agri-food products and means of production as well as collecting and spreading market information in this scope
6. Development of entrepreneurship in the rural areas	6. Conditional variety experimentation conducting as part of the post-registration variety experimentation
7. Modernization of the rural household	7. Dissemination of the agricultural production methods and the environmental friendly lifestyle
8. Applying for the financial aid granting or for the aid co-financed by the European Union funds or by other national or foreign institutions	8. Taking measures to preserve the cultural and natural heritage of the rural areas as well as to arrange the organic and functional agricultural holding
9. Modernization of agricultural holdings, improving the quality of agri-food products and their processing as well as strengthening farmers' position on the market	9. Promotion of agricultural and rural tourism development as well as promoting rural area as an attractive place to rest
10. Management of agricultural holdings	10. Cooperation in implementing tasks from the agri-environmental and action programmes aiming at reducing nitrogen outflow from agricultural sources
11. Promotion of local and regional products	11. Conducting the analysis of changes in the scope of the level and quality of agricultural production and the functioning of agricultural holdings as well as disseminating the results of advisory work analysis

Source: The act on the agricultural advisory units from 2014

Advisory services are certainly not new in many Member States, but they may have been taking place in a piecemeal manner. By obliging each Member State to have a FAS in place, the legislator has adopted a more strategic overarching approach. The efforts being made in the Member States illustrate the important role that the system and the FAS coordinating bodies can play in helping farmers understand and implement EU rules.

The farm advisory system in Poland was based on European and national law provisions. The regulations of the Council of the European Communities from 2003 constituted the legal basis for the system existing in the whole European Union. The subsequent key legal act was the Council Regulation (EC) from 2009, which maintained the requirement to establish and organize the agricultural farm advisory service centre, indicating the additional scope of services resulting from the implementation of cross compliance. Legislative modifications aimed at providing the instruments of market control and forming strategic guidelines of the Common Agricultural Policy. The list of priorities was expanded to embrace the so called new challenges concentrating on counteracting climate changes, preservation of biodiversity, promoting renewable energy generation as well as on conducting rational water management. These issues were also embraced by the agricultural farm advisory service.

The Farm Advisory System (FAS) in Poland involved public institutions, including the Central Agricultural Advisory service and 16 regional Agricultural Advisory Centres. The Chambers of Agriculture had the right to advise pursuant to a law, without the requirement to apply for accreditation. Apart from the public advisory system, national regulations authorised private advisory units for the transitional period (until 2015) which had to apply for accreditation in the Ministry of Agriculture.

The advisory system in the period under study implemented a lot of crucial tasks and in this sense it fulfilled the basic and essential role in the FAS system. It involved the activities in the scope of agriculture and development of rural areas, agricultural markets as well as rural households. These activities aimed at increasing agricultural income levels, improving market competitiveness of farms, supporting sustainable development of rural areas and improving vocational qualifications of farmers.

Agricultural farm advisory service was responsible for adjustment processes of rural areas and agriculture to the requirements of the competitive economy in the European Union. At the national level, it created the need to develop a new perspective on the place and role of agricultural farm advisory service. The expectations of farmers towards the farm advisory service services depended on the features of the community they were directed at and on the problems, which agricultural producers faced. Taking those factors into account was equally significant as the new activities, which consultants obtained from the Common Agricultural Policy. When specifying the functions of agricultural farm advisory service from this point of view, it should be stated that over the last dozen years, economic polarisation of farms has been gradually increasing and farmers stopped or reduced agricultural production in a lot of agricultural holdings. The considerable number of farms ceased to run agricultural production at all. As a result of restructuring and modernisation of farms, the needs of farmers regarding advisory services have changed. The expectations towards advisers were increasingly related to the issues regarding the possibilities that the policy provided in respect of rural areas and agriculture for those farms, which had been excluded from the agricultural market due to different reasons or had taken a marginal position on the market.

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HOW TO GUIDE STUDENTS GOING TO PRACTICAL TRAINING IN AGRICULTURAL STUDIES?

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Abstract. *During the studies in the agricultural field, a practical training on real farms or other agricultural enterprises is a key element to learn and apply things in practise. To manage their practical training, agricultural Bachelor of Natural Resources (BNR) students require plenty of guidance throughout the process. The needs of guidance for agricultural BNR students were studied during the spring 2010 in Savonia University of Applied Science, Iisalmi, Finland.*

According to the results, some crucial features of the whole process of guidance of the training were outlined. First of all, the whole training process should be well defined, scheduled and mentored, including financial advice. Secondly, a sufficient number of already contracted training farms, other enterprises or international exchange connections should be available and the tasks and circumstances for the training and intern should be well documented and updated. Thirdly, students need flexibility in the training process and they appreciate the alternative of international exchange as a training, so this should be actively promoted by the school personnel. Finally, to make the training a success for the student, the training farm or enterprise should be informed to give an abundant amount of guidance to the student, especially with the tasks that interns consider difficult or risky.

Key words: *agricultural studies, training, internship, guidance.*

INTRODUCTION

Performing a training on farms or other agricultural enterprises is an essential part of the learning process on an expertise field like agriculture, were students need to adopt a broad variety of both scientific knowledge and competence in practise [1]. To promote the practical learning of Bachelor students of agriculture in Universities of Applied Sciences in Finland, typically at least two training periods are obligate for students for graduation. Usually, the first of these must be carried out on an ordinary farm and the second on other kind of agricultural enterprise or e.g. in advisory or research institution working as an agricultural expert.

In Savonia University of Applied Sciences, Iisalmi, Finland (Savonia), the studies for the degree of Bachelor of Natural Resources (240 ECTS credits in total) contains two training periods. The first practical training period is carried out after the first study year, covering the whole growing season. The width of the training is 30 ECTS credits, which means 80 working days (á 8 hours). The second practical training (20 ECTS credits, 70 working days, á 8 hours) is carried out after the third study year in organisation on agricultural or equine field, e.g. in advisory, research, governmental or commercial organisation. The whole process of educating students for the degree of Bachelor of Natural Resources in Savonia has been awarded with the nomination of Centre of Excellence in Polytechnic Education in 2009 by the The Finnish Higher Education Evaluation Council FINHEEC [2]. One argument for this award was the successful incorporation of two different practical trainings into the degree programme.

There are no recent reports on studies concerning the evaluation of the actual process of guidance in the practical training in agricultural schools in Scandinavia. The mentoring and tutoring process of vocational training of agricultural students (Bachelor of Natural Resources) was studied in Savonia, during spring 2010 as a part of MSc Mäkiniemi's pedagogic studies for vocational teacher. The main aim of the study was to reveal the needs of interns for guidance in the whole training process and to find both good practices and weaknesses in the promotion of interns during different phases of the training: in finding and contacting the training farm or other enterprise, preparation for the training (including the paper work needed to report the outcome of the training) and during the actual training period.

MATERIALS AND METHODS

The survey for the study was conducted in Savonia during spring 2010, before the start of the intern period, using a feed-back program Typala, which is typically used to collect course or seminar feed-back from the students. The group of students that was subjected to the survey consisted of first and third year students (Bachelor of Natural Resources, BNR), who were preparing for their first or second intern period. The mailing list and the exact number of students receiving the survey questionnaire were kept confidential at the university, but the group consisted of approximately 60 students.
The questions included both scaled questions (nominal or ordinal scale) and open text questions. The results were transferred to Excel. In the case of scaled questions, the frequencies, percentages and medians for answers were computed. When applicable, the results were analysed using t-test e.g. for comparing male and female students or the ones having their first or second training (the TTEST procedure) or linear regression models (the REG procedure) in SAS (version 9.2 with EG 4.2, SAS Institute Inc., Cary, NC, USA). The results for open text questions were analysed and reduced into topic level and faded out in the cases of confidential information.

RESULTS AND DISCUSSION

In total, 31 answers were obtained, but 7 of these were unusable due to technical problems that had occurred within Typala during the answering process. 24 valid answers were collected consisting of answers from 14 female and 10 male students in Savonia. Nine answers were obtained from first time interns (first year students) and 15 from second time interns (third year students).

Guidance from the personnel of Savonia

Generally, the interns were highly motivated to carry out their training (Figure 1). There were no significant differences between the first or second time interns or between female or male students, with the exception of the male second time interns, who formed a distinct group with a very high motivation towards their upcoming training ($p<0.0001$).

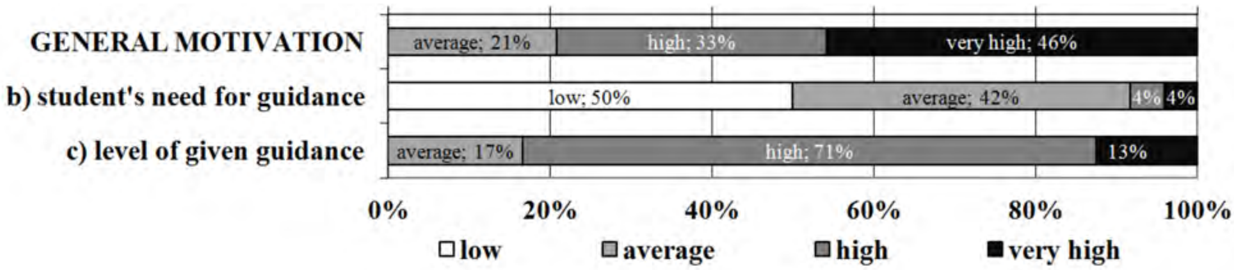

Figure 1. **The general motivation towards the training period and the needed and gained guidance from the personnel of Savonia University of Applied Science (Savonia) before the training period of interns (n=24) in agricultural practical training.**

According to the results from the scaled and open text questions, the most typical source of motivation was the opportunity to gain both experience and competence in their own field. Also new contacts and some awaited forthcoming tasks in the agricultural field were mentioned as a source of motivation. The payment for the work or the opportunity to start working on a Bachelor thesis were not the main motivating reasons for any of the students.
All students expressed the need for guidance from the personnel of Savonia during the training process (Figure 1). Nevertheless, some of them claimed to manage the whole process with minimum help or guidance from any other person. A bit surprisingly, the ones needing most guidance were second time interns ($p<0.12$), but the increased need for help was mostly associated with attempts to find the training place by themselves or with their plans to do the training via an international exchange, which both concern more paper work especially before but also after the training.
The level of given and gained guidance was very good, as 84% of all interns considered having high or very high amount of guidance from the personnel of Savonia (Figure 1). The level of guidance seemed to exceed the expectations or needs of some students, as the level of gained guidance was greater than the reported need for it.

In the open text answers, the quality of guidance was in some cases criticized; this was associated with the fact that the number of training farms, especially equine farms, which had an existing trainer/trainee contract with Savonia, was not sufficient and the students wanted to try to find the farm on their own.

Good practices and weaknesses in the guidance process

According to the results of the open text questions, the good practices in the guidance process inside Savonia included the following issues (the percentage of students to give such feed-back are shown):

a) The personnel had helped and guided with the all the paper work concerning the process (25%)
b) The personnel have been flexible according to the choice of training enterprise and/or have encouraged pursuing an international training exchange (25%)
c) The school has a good number of already contracted training farms or other enterprises (21%)
d) The school has described well enough the work and tasks in each contracted training farm or enterprise (21%)
e) The whole training process is well defined, scheduled and mentored (21 %)

There were some issues that were concerned as weaknesses or in need of re-evaluation or improvement:

a) There is a need to have more already contracted training farms or enterprises, especially for equine studies or/and for international exchange (21%)
b) The level of payment for the intern during the training should be improved and the means to combine payment and social student aid should be informed by the school personnel (21%)
c) The quality and amount of the description of the contracted training farms or enterprises should be improved (21%)
d) The whole process, timing and the requirements to the student to apply for training should be clarified (8%)

There were three issues that emerged both as good practices and weaknesses: the number and type of contracted training farms or enterprises, the description of the work at the training places and the whole training process as a part of the BNR studies.

According to closer analysing of the open text answers concerning the number of contracted training places, the negative feed-back answers were mostly from students having equine husbandry as their specialization subject and who did not find their training place via Savonia, but ended up finding the farm or enterprise by themselves. Apparently, this was not an easy process to carry out and it caused a lot of frustration and disappointment.

In some cases, the available work and tasks on the training farms or other enterprises described by Savonia and later on the ones described by the farm or enterprise personnel (e.g. during an interview or other communication during the seek for a training place) were not convergent, which was a disappointment to the intern. This was probably subject to the extension or specialization of the some system on the farm or enterprise after the description for Savonia had been done. These changes inside the training place might have changed the type and number of tasks that were available to the interns to do. There were also some mentions from the students that the palette of different tasks might depend on the sex of the intern, i.e. male interns are expected to be able to handle more machinery work than female interns or that the work with animals is preferably given to female interns.

The university is probably unable to affect the level of actual payment for the intern during the internship, but it could enhance the level and quality of financial guidance for students as a part of the mentoring process. The number of students having serious problems in the training process and its guidance was small. Nevertheless, each of these must be solved and in this, social skills of the personnel - both at the university and at the training place – are a key value.

Guidance needs from the personnel of the training farm or other training enterprise

Concerning the actual internship and training period, the students were asked about the tasks or issues they consider to need guidance at the training farm or other training enterprise. Overall, all students reported to need average or plenty of guidance during the period of their internship (Figure 2). Surprisingly, second time interns tended to report to need slightly more guidance that the first time interns, which might be associated with more demanding tasks they expect to be given during their internship.

Students considered that they need plenty or even continuous guidance in the practical work in general and in the machinery and in work which includes chores with information and computer technology (Figure 2, sections a, j, k). The high need for general guidance correlated positively with the need of guidance in practical (r^2=0.34; p=0.003) and machinery work (r^2=0.32; p=0.004). Female students were more likely to report a higher need for guidance in practical, machinery and computer work, but the difference between female and male students was significant only when considering computer work (p=0.013).

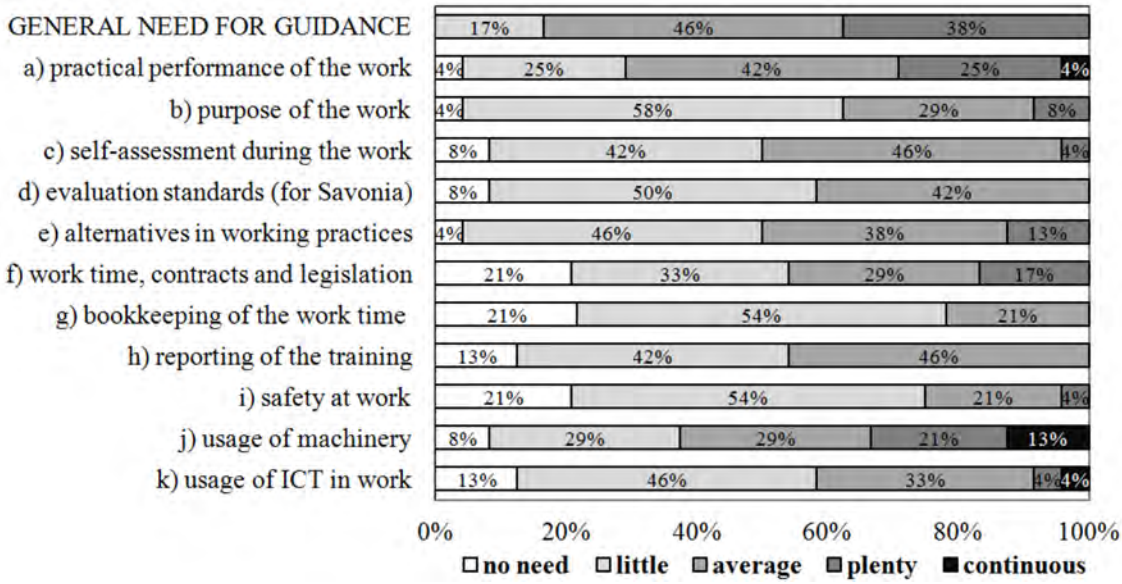

Figure 2. **The expected need for guidance in different tasks or issues at the training farm or other training enterprise during the upcoming training period of interns (n=24) of Savonia University of Applied Science (Savonia) before an agricultural training. ICT = information and computer technology.**

Other tasks or issues needing plenty of guidance were the purpose, self-assessment, alternatives and safety in the work (Figure 2, sections b, c, e, i). There was a high positive correlation between the need of guidance in machinery work and work safety (r^2=0.51; p<0.001), which probably indicated that students consider machinery work as a high-risk part of their tasks. Students needed also guidance in the legislation and contracts concerning their work (section f). Bookkeeping of the working time, reporting of the actual tasks or the standards for evaluation of their own performance were considered as the easiest part of their internship, as none of the students considered to need plenty of guidance in these issues (Figure 2, sections d, g, h).

There was a small group of male students who were heading to do their training on farms they already know and have worked at, and considered that the “paper work” (bookkeeping of working time, legislation, contracts etc.), work with machinery and safety at work were not an issue to require any guidance at all.

As the survey was done prior to the training and was not repeated after it, most students were unable to evaluate the good practices or weaknesses in the guidance of their training farms or other enterprises. Some reported, that the personnel on their training places have helped them significantly by advising them about the upcoming tasks during the training, about the clothing or other apparel they need to take with them, or that they have helped them in arranging an apartment.

The training farms and other enterprises might need information on which issues to concentrate in their own guidance. The results of this study can be used when creating or updating these instructions: guidance in machinery work and with information and computer technology are the most important, followed by other issues related to the actual practical performance in the work. Also the safety issues should be a high priority, especially under the circumstances where the intern is starting to use previously unknown machinery or technology, or when working with animals.

CONCLUSIONS

Agricultural Bachelor of Natural Resources students require plenty of guidance to manage their vocational training periods. Their school should maintain high standards and if possible, improve in following issues:

a) The whole training process is well defined, scheduled and mentored. Also the financial facts are included into the information.

b) A sufficient number of already contracted training farms, other enterprises or international exchange connections are available, with the tasks and circumstances for the training and intern are well documented and updated.
c) There is flexibility in the training process and the alternative of international exchange as a training is actively promoted by the school personnel.
a) The training farm or enterprise is informed to give an abundant amount of guidance to the student, especially with the tasks that interns consider difficult or risky to themselves.

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