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LAMMC

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Põllumajandus- ja keskkonnainstituut

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FACULTY OF AGRICULTURE, LATVIA UNIVERSITY OF AGRICULTURE

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In the structure of Faculty of Agriculture (hereinafter – Faculty) two institutes, Research and Study farm „Pēterlauki” (hereinafter – Pēterlauki) and Laboratory for testing of value for cultivation and use of agricultural crop varieties (hereinafter – Laboratory of VCU) are included. Institutes were founded in 2005: Institute of Soil and Plant Sciences and Institute of Agrobiotechnology. Now, Faculty is on the threshold of possible changes and discussion is opened about the necessity of institutes and their role in research and study process. Also, Pēterlauki has changed. Before the year 2015, it was field research farm for Faculty staff trial needs, but now it is a large unit which includes also former horse breeding centre “Mušķi” as a department, and another field research department needed for Laboratory of VCU in Latgale Region – Višķi. Laboratory of VCU was founded at Faculty in 2012 when it was decided by Ministry of Agriculture to give the official variety trials in charge of Faculty. All these structure units take part in research and study activities of Faculty.

In 2015, a new strategic plan was worked out at the Latvia University of Agriculture (LLU) and also Faculty has set new objectives. The main directions and functions are replaced. Before the new strategic plan was implemented, the main direction of University and Faculty was provision of higher education, namely for Faculty – higher education in Agriculture (Agronomy, Zootechnics and Entrepreneurship in Agriculture), but now it is research. The main research directions for Faculty are described henceforward. **1. Research of microorganisms and invertebrates important to agriculture.** This direction includes the following topics: research of rhizobia (*Rhizobium spp.*) and their strains, assessment of their efficiency and compatibility with host plants (peas, beans and other legumes), research of their biological and genetic diversity; interaction between different groups of microorganisms (rhizobia and mycorrhiza fungi); life cycles of plant pathogens (mainly from the *Ascomycota* division and *Deuteromycetes* group), biology and ecology of pathogens; occurrence of wheat root rot and the spectrum of its causal agents and diversity depending on the agronomical measures; occurrence of barley ear scab and the spectrum of their causal agents depending on the agro-ecological conditions; invertebrates (ground beetles and rove beetles) as environmental indicators; occurrence and harmfulness of cereal pests, their life cycles and natural enemies. **2. Research of soil and land as the main resource of agriculture.** This direction includes such topics: soil diversity and protection; the role of soil in the formation of environmental risks (CO_2 and other greenhouse gases emissions leaching and run-off of biochemically active substances) and agricultural technologies for the reduction of such risks; changes in the characteristics of the soil using different agricultural systems – intensive production, extensive use of resources, biological agriculture, site specific (precision), different soil tillage methods and crop rotation schemes etc.; methods and techniques of fertiliser use for increasing efficiency and reducing environmental risks; studies on chemical element cycling in agriculture; sustainable crop rotation and soil tillage methods and techniques by adjusting them to different agricultural systems and environmental conditions; changes in weed species and their occurrence depending on different agro-ecological conditions. **3. Improvement of plant productivity and quality of harvest by using environmentally friendly technologies.** This direction includes further mentioned topics: the formation of structural elements of wheat, oilseed rape and other crop yield in crop rotation and repeated sowings depending on the soil tillage method; differences in the cold resistance (resistance to low positive temperatures) of maize hybrids and their influence on the growing, development and yield; influence of the sowing density and harvesting time on the yield its quality and the formation of mycotoxins in the yield; suitability of various energy crops for the production of biogas – more methane with a reduced climate risk; the determination of maximum nitrogen fertiliser rates for maize, hemp, legumes and other crops; research on the occurrence and harmfulness of pests in crop rotation and repeated sowings or monoculture – wheat, field beans, maize etc.; high-quality pasture swards for different species of animals; evaluation of forage contamination with mycotoxins in Latvian farms; growing of alfalfa and its use in industrial processing; propagation of *Vaccinium* spp. (high-bush blueberries, cloudberries, red bilberries, cranberries), biological aspects of winter hardiness; physiological aspects of ornamental plant propagation, growing technologies, substrates, fertilisation; research of genetic resources (aromatic, medicinal and other plants, bees), conservation of the genetic recourses. **4. Improvement of animal productivity and functional efficiency.** This direction includes such topics as: improvement of the productive characteristics of Latvian farm animals by using molecular methods; suitability of the various species of farm animals imported into Latvia to the conditions of Latvia; development of animal feeding and keeping systems for farm animals that are suitable for Latvian conditions and are economically viable; development of programmes for ensuring the health of animals for different types of farms in Latvia (including organic farms); research of animal welfare, adaptation processes and behaviour of traditional and non-traditional species of animals; development of new feed or feed additives and new feed processing technologies, their testing; research of the farm animal feed composition impact on the environment and climate (including methane emissions); research of the morphofunctional processes of non-traditional animal species (for example, ostriches, deer, edible snails) and the influence of these processes on the quantity and quality of the obtained production.

Part of above mentioned topics are developed within EU FP 7 program EUROLEGUME, two huge projects of State Research Program and several projects financed by Ministry of Agriculture of Latvia. Also smaller problems ordered by producers are solved. Currently, the main problem is funding because stress is put on European scale projects, but competition in this scale is cutthroat. The State of Latvia does not allocate funding for research; another stress is placed on interests of producers who should pay for scientific solutions even in bigger or fundamental research scale. Unfortunately, currently the majority of producers wants to have the solution for their problem, but they do not want to pay as they consider that it is the responsibility of the State. This is like a vicious circle.

Great responsibility and challenge is the provision of higher education in agriculture, and Faculty is still the only place that provides this kind of education in Latvian language in Latvia. Last year (2015) a scientific paper in which bachelor level higher education in Baltic Region was compared was published in Proceedings of NJF Congress held in Riga in 2015 (co-authors from Estonia and Lithuania were Evelin Loit and Viktoras Pranckietis, respectively) (Proceedings available at: http://njfcongress.eu/images/PROCEEDINGS_of_the_25th_NJF_Congress.pdf). Interest about education in agriculture from young people currently is stable in Latvia and also working places are available in the country: even in Faculty we have a lot of requests for specialists. The problem is continuously diminishing population in Latvia, funding of higher education at the level of 85% from needed minimum since the crisis in 2009, and incapability to compete with the sector recruiting new people as future teaching staff and researchers.

The point of reference for students' number is 1 October of each year. Total number of bachelor level students varied from 350 to 400 depending on a year, and it was 378 on 1 October 2015. At the same time we had 52 master students (it was a record during the last 6 years; we have only 30 budget financed places) and 26 doctoral students. Since European Social fund grants are not available anymore for doctoral students, an interest about these studies has decreased. The number of graduates is very important since the sector has a continuous demand for specialists. This year we hope that 57 (54% from matriculated) professional bachelors and 20 (71% from matriculated) Masters of Agriculture will celebrate their Graduation Party on 22 June. We have some dropout as it is seen by calculated percentage of graduates from matriculated students. Causes of dropout are different – quite poor preliminary knowledge, though a very usual reason, especially for master students, is inability to combine studies with job.

Faculty is still thinking about closer co-operation with Estonian and Lithuanian colleagues in master level. We consider that this can be a good possibility not only for students of all three Baltic countries but also for exchange students from other regions.

Eesti Maaülikool EMÜ Estonian University of Life Sciences

Eesti Maaülikool EMÜ Põllumajandus- ja keskkonnainstituut

DEVELOPMENTS IN THE INSTITUTE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES OF ESTONIAN UNIVERSITY OF LIFE SCIENCES

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The Institute of Agricultural and Environmental Sciences (IAES) was established in 2005 by merging six of ten research and education institutions, which comprised the Estonian University of Life Sciences (EMÜ) including the Faculty of Agronomy. The IAES is responsible for research and development, and university level education in plant cultivation and plant biology, horticulture, plant health, soil science and agrochemistry, landscape ecology and management, landscape architecture, biological diversity and applied hydrobiology in Estonia. The IAES is the largest of the five institutes of EMÜ and attracts 74% of the research financing and 25% of the students at the University (Institute of Agricultural and Environmental Sciences, 2015).

The biggest change for the IAES during recent years was the opening of the Science Centre of Renewable Resources in 2013, the new building bringing together researchers, teachers and students from different former locations outside the campus. The new part of the building on 5100 m^2 includes new rooms for laboratories, seminars, offices and ca 600 m^2 for the biological collections, such as herbarium, mycological and entomological collections as well soil museum. All together IAES got 11 000 m^2 new or renewed modern facilities in the campus.

In 2015, the 130 m high Station of Measuring Ecosystem-Atmosphere Relations (SMEAR) was opened at Järvselja, allowing measure concentrations and fluxes of energy and matter in the atmosphere—biosphere system (Station for …, 2016). In the same year the Competence Centre for Knowledge-based Health Goods and Natural Products (PlantValor) in Polli and renewed Võrtsjärve Study Centre at Lake Võrtsjärve were opened too. In Polli competence centre the new plant substances based products are developed in cooperation with different food, cosmetics and pharmaceutics companies.

Currently, the institute has 11 departments, two research centres and one experimental station. IAES is also involved in the activities of several interdisciplinary centres in the university. No structural changes were made during last three years. However, in the spring of 2016 the process to reorganize university responsibility areas and to emerge too small departments into bigger chairs started again.

The annual budget in IAES is 6.4 million Euros, from which 28% comes from teaching, 10% from international research and 38% Estonian research grants. Rest of the budget forms from different local and international contracts. Due to the end of EU financial period, some decrease of research funds and the number of academic staff was evident in 2015 compared to the 2014 and 2013. The number of academic staff decreased from 127 to 106 and the number of different contracts from 144 to 118, and sum of research money from nearly 48 000 to 43 000 EUR. At the same time the income per academic person increased from nearly 34 000 to 40 400 EUR. In the field of agriculture an average income per academic person is 22 000 EUR.

The new centre of excellence Ecology of Global Change: natural and managed ecosystems (EcolChange) started in 2016. The EcolChange is led by Professor Ülo Niinemets and the leading University is Estonian University of Life Sciences. The EcolChange is one of the nine Centres of Excellence in Science in Estonia. In the field of agriculture one Horizon 2020 project was started in 2015 – Interactive Soil Quality Assessment in Europe and China for Agricultural Productivity and Environmental Resilience (ISQAPER), where Estonia is one of the partners. There is also running one FP 7 project – Quantification of Ecological Services for Sustainable Agriculture (QUESSA). The list of other recent main research topics as well as international and local research projects and contracts can be found in the institute booklet (Institute of Agricultural and Environmental Sciences, 2015). However, in the field of agriculture, the majority of the projects are applied research projects or contracts.

Publication of high level (Web of Science – WoS) papers increased from less than one to 1.08 and 0.75 per academic person per year in IAES and in agricultural area separately, respectively. The average of the university is 0.48 WoS papers per academic person per year.

Our teaching and learning take place in a research environment where students benefit from interaction with researchers who are working at the frontiers of knowledge in their disciplines. We have seven bachelor, seven master and two doctoral degree programmes running on the responsibility of our institute at the moment. All study programmes are based on accredited curricula and teaching at IAES is of a high European standard. Due to the changes in the higher education law, several curriculum names were changed and some curricula were closed in 2013. In Estonia, since 2013 the education for full time students is free of charge on every curricula if the study language is Estonian. In the field of agriculture the bachelor curricula Production of Agricultural and Horticultural Products with two specializations earlier, was spited for two separate curricula's, such Production and Marketing of Agricultural Products and Horticulture, to be more visible and attractive for the students. The distance learning bachelor curricula Farm Management program was closed for admission, does not compete with the above mentioned programme as no tuition fee has been allowed also for distance learning students since 2013. The master degree programme Crop Technologies and Product Development was opened in 2012 but closed again for admission in 2014 due to the low interest of the students. The main reason of closing of the curricula's is the decreasing number of students due to the demographic situation in Estonia. If in 2012/13 academic year there were 1452 students at IAES, then in the spring 2016 we had 916 students, from which 1/3 were agricultural students. The number of agricultural students decreased from 547 to 341 during last years (Fig. 2). The number of admitted and graduated students is decreasing as well. However, the satisfaction with the studies remained high and students appreciated professionalism of our teachers and study environment.

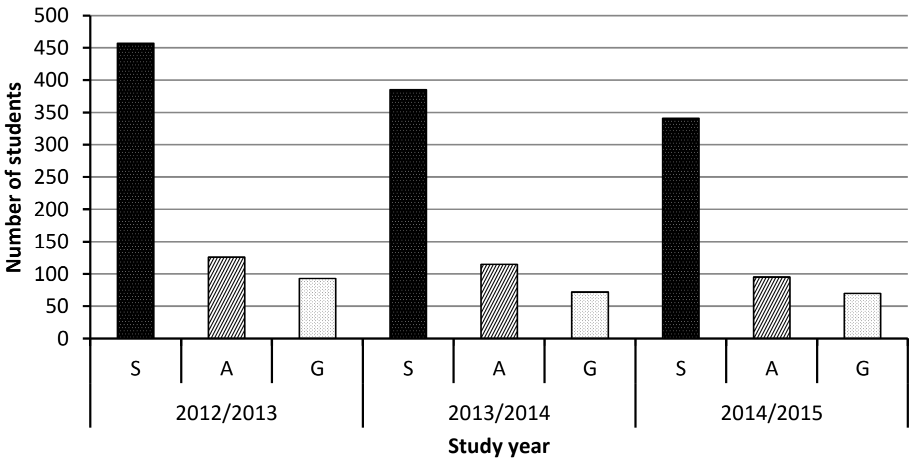

Fig. 2. Number of agricultural students in IAES in bachelor and master level: S – students; A – admitted students; G – graduates.

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RESEARCH ACTIVITIES AT ALEKSANDRAS STULGINSKIS UNIVERSITY AGRONOMY FACULTY

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At present, teaching staff of the Faculty includes 40 professors and assoc. professors. The main fields of research are: agroecosystem sustainability and ecological intensification; development of environment and resource conserving and competitive agrotechnologies; increase of plant genetic potential in coherence with environment, stands productivity and growth modelling; development of safe food and raw materials for innovative industrial production. There are three Institutes at the Faculty: Institute of Agroecosystems and Soil Science, Institute of Biology and Plant Biotechnology, Institute of Agricultural and Food Science.

Institute of Agroecosystems and Soil Science. The mission of the Institute of Agroecosystems and Soil Science is to conduct the scientific research in the area of agro-ecosystems and soil sciences to perform training of specialists in the first, second and third studying stages. The vision is to become a famous scientific institution and a centrum of specialists' education in the Baltic States in field of soil sciences, optimization of yielding conditions of agricultural plants communities and organic farming.

Research topics

- The improvement of Lithuanian soil classification.
- The regularities of changes in soil properties and plant yield formation while influenced by natural and anthropogenic factors.
- The theoretical and practical basics of organic farming.
- The optimization of yielding conditions of agricultural plant communities using husbandry instruments.

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Institute of Biology and Plant Biotechnology

The mission is to apply the latest scientific achievements, to contribute to education of highly skilled and strong morality professionals, to develop research in the fields of Agriculture, Forestry, Biology, Botany (and etc.) of Agricultural and Biomedical Sciences, to disseminate knowledge to the public. The Institute is a division of the Agronomy Faculty, maintaining business relations with the various divisions of the University and other institutions, open to the cooperation with foreign partners, carrying out the development and dissemination of educational and scientific functions, providing decent working conditions and development of staff and students.

The Institute carries out studies and research related to the plant biology (Botany, Physiology), plant protection (Entomology, Zoology, and Phytopathology), biotechnology, microbiology.

Research topics

- Agro ecosystem sustainability and ecological intensification.
- Increase of plant genetic potential in coherence with the environment.
- Development of environment and resource conserving and competitive agro technologies.

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Institute of Agricultural and Food Science

The mission of Institute is to develop fundamental and applied research in Agricultural and Food sciences, to educate competitive highly qualified graduates and scientists, to systemize and disseminate scientific knowledge so that each Lithuanian citizen could use safe and healthy food as well as live in the full-fledged environment.

The subjects of research and studies activities are agricultural plants, their biological potential modelling and realization, the quality of plant based food raw materials and animal production as well its improvement.

Research topics

- Development of environment and resource conserving and competitive agro technologies.
- Development of safe food and raw materials for innovative industrial production.

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Research Laboratory of Plant Biotechnology

Fields of activity. Development of initial materials for spring/winter rapeseeds and linseed flax breeding; increase of genetic variability of oilseed crops by different biotechnological methods; development and screening of new oilseed crops gremplasm with biotic/abiotic stress resistance using *in vitro* cultures; study of the inheritance of *Brassica napus* seed colour and development of yellow-seeded genotypes; development of molecular markers linked to various traits of oilseed crops; Agrobacterium – mediated transformation of rapeseeds.

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Research Laboratory of Plant Products Quality, Zootechnical and Agronomical Analyses

Fields of activity: evaluation of plants raw and produce quality; investigation of soil, animals produce quality and composition.

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Research Laboratory of Plant Raw Materials Quality

Fields of activity. Investigation of plant raw materials chemical composition using non-destructive analytical methods, evaluation of chemical composition of plant raw materials, storage of plant raw materials in modified atmosphere, sensory analysis of food materials and products, testing of harmful organisms biology, ecology, physiology, toxicology in controlled environment, evaluation of bee races DNA, maternal pheromone and analysis of bee products quality, determination of mycotoxins, heavy metals and pesticide residues in agricultural products.

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Experimental Station is involved in creation, introduction and dissemination of new technologies. The crop production technologies that have been created and improved at Experimental Station are introduced in farms in different regions of the country.

Research topics

- Optimization and ecologization of crop formation and potential capacity by soil management means.
- Investigations of growth, development and yield formation of field and grassland crops.
- Investigations of spread, damage and control measures of pests and diseases.
- Development of growing technologies of main marketable crops of Lithuania (sugar beet, wheat, oilseed rape) ensuring their competitiveness in domestic and foreign markets.
- Economic feasibility and agro-engineering of reduced and ploughless soil management, and direct drilling in our agro-climatic conditions.
- Investigations of cultivation and use possibilities and technologies development of non-traditional crops (spelta wheat, safflower, soy) in Lithuania.
- Investigations of organic farming and development effect on agro-ecosystem.
- Investigations of crop adaptation in changing climate conditions.

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AGRONOMY RESEARCH IN LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY

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Elaboration of research and experimental activities in the agricultural and forestry sector vitally important for the development of national agriculture and forestry economy. Lithuanian Research Centre for Agriculture and Forestry (LAMMC) as a state research institution is one of the leading research institutions, which carries out research in the fields of agronomy, forestry, ecology and environment sciences and experimental development as well as contributes to the development of modern agricultural and forestry sector. The mission of LAMMC is the conduct of basic and applied research relevant for science, national economic development and ecological needs, rational and sustainable use of land, forest and environmental resources and high quality production in compliance with the envisaged major directions of the scientific activities; development of experimental and other activities in the fields of agronomy, horticulture, forestry science, ecology and other related braches; accumulation of new scientific knowledge, its systemization and dissemination to the public; promotion of balanced and sustainable land and forest economy and rural development. LAMMC consists of institutes (Institute of Forestry, Institute of Horticulture and Institute of Agriculture), regional branches and research departments, other administration and economy divisions. The Centre's management bodies are collegial management body - the Centre's Science Board and one-man management body - Centre's director. Various committees, necessary for streamlined and effective activities of the Centre are formed.

Research and its organization. The LAMMC scientific potential, the existing and regularly being updated experimental base enables the conduct of interdisciplinary and inter-branch research, development of science attractive to agricultural and forestry business. According to the nature of research organization, funding and topics, the LAMMC research is divided into several groups. Firstly, it is institutional state-funded research, from which six major, long-term institutional programmes have been formed: i) Biopotential and quality of plants for multifunctional use, ii) Sustainable forestry and global changes, iii) Harmful organisms in agro and forest ecosystems, iv) Horticulture: agrobiological foundations and technologies, v) Productivity and sustainability of agricultural and forest soils, vi) Genetics and purposeful change of genotypes of agricultural and forest plants.

The Centre carries out research and implements various programmes and projects obtained by tender funding method and funded by the Ministries of Agriculture, National Economy, and Environment; conducts various research and experimental development projects contracted by foreign and national economic entities, participate in international scientific and development programmes.

LAMMC was granted a right for doctoral studies in 4 science fields: agronomy and forestry research jointly with Aleksandras Stulginskis University, ecology and environment research jointly with Vytautas Magnus and Aleksandras Stulginskis Universities and Natural Research Centre, biochemistry – jointly with Vytautas Magnus University, Lithuanian University of Health Sciences and Nencki Experimental Biology Institute (Poland). The doctoral studies provided by LAMMC conform to the contemporary goals of agricultural and forestry sciences, up-to-date methods and facilities are used in research work.

To make better use of scientific knowledge and to address the multifunctional agricultural problems, the staff of LAMMC actively joined the governmental program of science, education and business development "Nemunas". For more active development scientific services LAMMC has founded Fruit and Vegetable Processing Technologies Simulation Open Access Centre and Open Access Centre for Agrobiological Research. Open Access Joint Research Centre of Agriculture and Forestry was setup together with Aleksandras Stulginskis University.

LAMMC in cooperation with Lithuanian, Latvian and Estonian research and study institutions published scientific journals Žemdirbystė-Agriculture (www.zemdirbyste-agriculture.lt) and Baltic Forestry (www.balticforestry.mi.lt) with impact factors and referred in Web of Science™ database.

LAMMC uses various methods to transfer the research information to its consumers – researchers, farmers, foresters, agricultural experts and advisors, teachers of agricultural schools and the general public. Each year, LAMMC organizes scientific conferences, seminars, field days, researchers publish more than 150 scientific articles, more than 100 popular scientific publications. New crop cultivation technologies or their components, new varieties and other valuable information on the issues of agriculture and forestry are introduced in popular publications, recommendations, information booklets etc. For most topical information please visit LAMMC website: www.lammc.lt.

Institute of agriculture in LAMMC community. The Institute of Agriculture (Institute) is one of the most important representatives in agronomy and related fields of science. The Institute has its origins in the beginning of the 20th century, when the first research stations were set up in Dotnuva (Dotnuva Breeding Station and Dotnuva Experimental Station). The Lithuanian Institute of Agriculture was established in 1956 having amalgamated the Institute of Agriculture and Soil (in Trakų Vokė) with the State Breeding Station (in Dotnuva) and the Dotnuva Experimental Station. Other experimental stations operating at that time in various regions of the country were incorporated into the system of the Institute. In the course of history, significant developments and reorganizations have taken place in the research institutions. Upon the restoration of Lithuania's Independence, the Lithuanian Institute of Agriculture has become an independent state institute. In 2010, Institute was joined to the LAMMC as a stem Institute.

Currently, the new knowledge, co-operation and openness are the major ambitions of the Institute of Agriculture of LAMMC. The mission of Institute is the conduct of basic and applied research, development of experimental activities in the field of agronomy and other related fields of science, accumulation of new scientific know-how and its dissemination to the public. There is a wide scope of research topics ranging from plant breeding and genetics to soil physics, from plant nutrition processes to diseases, weeds and pest management, from agricultural microbiology to sustainability of agroecosystems, to support mainstream objective of sustainable plant production under ever changing climatic and socio-economic environment. Long-term research plans of the Institute are broken into four long-term institutional state-funded research programmes of LAMMC.

Cultivation technologies of major agricultural crops have been developed at the Institute. The research results intended for practical application (farmers, agribusiness, policy makers, and public at large) are published in professional newspapers and journals, disseminated during practical seminars, field days, radio and TV broadcasts. A collection of short recommendations on farming is annually published and distributed among farmers and other stakeholders. More than 270 varieties of field crops have been developed in Lithuania during the whole plant breeding period. Many of newest varieties are successfully commercialised in Lithuania and in the USA, Canada, Estonia, Latvia and other countries, therefore development of new plant varieties is being continued.

Researchers of the Institute are encouraged to contribute with new topics of research, initiate and perform basic and applied research projects addressing relevant problems of the national economy, considering the regional pedo-climatic and farming conditions, as well as consumption patterns. They are constantly searching for novel and competitive crop cultivation technologies or their components meeting the environmental protection requirements and validated by appropriate agronomic solutions as well as for methods of obtainment and utilization of plant raw materials.

More about the structure, the researchers, their publications, projects and other information we invite you to access the website www.lammczi.lt.

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THE EFFECTIVENESS OF INOCULATION OF LEGUMES WITH RHIZOBIA

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Only prokaryotes have the ability to use the reserves of nitrogen of the air. Rhizobia forming on the plant roots nodules, in the symbiosis with legumes convert airborne inert nitrogen (N_2) in the organic form, which fits into plant proteins. At the end of vegetation, the plant death of soil per year enriched with nitrogen is in the range of 30 to 364 kg per ha. Enrichment plant with nitrogen, which is linked from the atmosphere with the help of bacteria, is an inexpensive and high-quality method of increasing crop yields (Zahran, 1999; Baddeley et al., 2014). In Latvia, studies of these bacteria were already launched by professor A. Kalniņš in the twenties of the last century. The Rhizobia collection, originally created by professor A. Kalniņš was supplemented by his students and same strains were included in several national rhizobium collections Worldwide. Nowadays, the Rhizobia collection of Latvia University of Agriculture, Institute of Soil and Plant Science, contains approximately 50 different streptomycin resistant rhizobium strains appropriate for all legumes grown in Latvia.

Nowadays intensive *Rhizobium* and their host plant studies are renewed not only in Latvia but also in the whole Europe due to their role in sustainable agriculture and protein crop production. Thanks to this activity the significance of Rhizobia collection is updated and part of it dealing with *Rhizobium leguminosarum* strains is included in investigations of 7th Framework program project „Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed" (EUROLEGUME).

The aim of the study was to investigate the effectiveness of symbiosis of fava beans (*Vicia faba*) and peas (*Pisum sativum*) with different *Rhizobium leguminosarum* stains in different soils of Latvia.

Experiments were established to evaluate the effectiveness of *Rhizobium leguminosarum* strains on legumes growth and productivity in the different soil types of Latvia. *Rhizobium leguminosarum* strains (RP023, RP003, RV407 and RV505) were from the collection of Latvia University of Agriculture. Experiments were done in Jelgava, Balvi, Jūrmala, Olaine, Vaidava and Sece region. Experimental fields included different soil types – sandy, sandy loam and peat soils. In the field experiments broad bean (*Vicia faba* var. *major*) cultivars 'Bartek' and 'Karmazyn', field bean cultivars (*Vicia faba* var. *minor*) cultivars 'Fuego' and 'Lielplatone', and pea cultivars 'Kelvedon Wonder', 'Vitra', 'Retrija' and breeding line 'H 91-14-43' were grown. Seeds were treated with suspension of bacteria before sowing. Control variant was without treatment with microorganisms. Plant length, amount of dry matter, weight and formation of nodules was analysed at the flowering stage. Number of pods, seed yield and protein content in seeds was examined at the end of experiment. Results showed that the growth and yield responses of legumes species and cultivars to inoculation with *Rh. leguminosarum* strains vary in different soil types and depending on weather conditions of growing season. It is observed that better results were obtained when for the inoculations of plants were used bacteria, obtained from the same species of crop. Different plant species have a different response to the treatment with bacteria. The best results of pre-sowing treatment with *Rhizobium leguminosarum* strains were obtained with grey peas and broad bean cultivar 'Bartek'. *Rh. leguminosarum* strain RV407, isolated from *Vicia faba*, was more appropriate for inoculation of broad bean seeds, while stimulating protein accumulation more than others.

Therefore for the establishment of effective preparations containing *Rh. leguminosarum*, bacterial association containing different strains is recommended.

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PULSES IN EUROPE AND IN ESTONIA

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Due to their nitrogen-fixing properties, leguminous plants contribute to soil fertility and have a positive impact on the environment. Additionally, legumes are a critical source of plant-based proteins and amino acids for people around the globe as well as for livestock. In both areas, fertilizers and protein crops, the EU has developed strong dependencies. On the one hand, nitrogen fertilizer consumption in the EU27 is about 10 million tons per year with an import share of 20 – 26% over the past four years. The production of nitrogen fertilizers is highly dependent on natural gas and the EU imported 62% of its overall gas energy needs in 2006 – 2010. On the other hand, 70% of protein-rich raw materials consumed in the EU are imported (42 million tons in 2009). Compared with other major agricultural regions in the world, the EU dedicates a relatively small area to legume crops and this has even decreased in recent decades. With regard to the potential ecosystem services delivered by legumes, there has been an increasing demand to strengthen the role of legumes in farming systems and agri-food/feed chains to meet agronomic, environmental and economic objectives.

The following databases were used: FAOSTAT, EUROSTAT, STATISTIKAAMET (Estonia). Field trial data was collected from the long-term experiment comparing the influence of organic and conventional farming systems on different crops yield and yield quality, soil fertility, nitrogen use efficiency. The field experiment was carried out near Tartu.

In the past three decades, global pulse production has grown rapidly. In the past ten years alone, the world has produced between 50 and 60 million tons of pulses each year. As of 2015, the world's biggest producers of pulses were India, Canada, Myanmar, China, Nigeria, Brazil, Australia, USA, Russia, and Tanzania, while the world's most important pulse exporters also include Argentina, France, Ethiopia, and Turkey. Because they are so healthy, nutritious and versatile, pulses are becoming a more popular choice for food manufacturers all over the world as an ingredient in breads, noodles, snacks, and gluten-free foods.

Legume family *(Fabaceae*) is the large family of dicots, including trees, shrubs, and perennial or annual herbaceous plants. There are approximately 13000…19000 species altogether, but only 200 are being cultivated. Humans have been using legumes for food for more than 9 thousand years. Legumes are also used in cosmetics and medicine, where they may have beneficial effect on those who suffer from Parkinson's disease, high cholesterol, cancer, alcoholism etc.

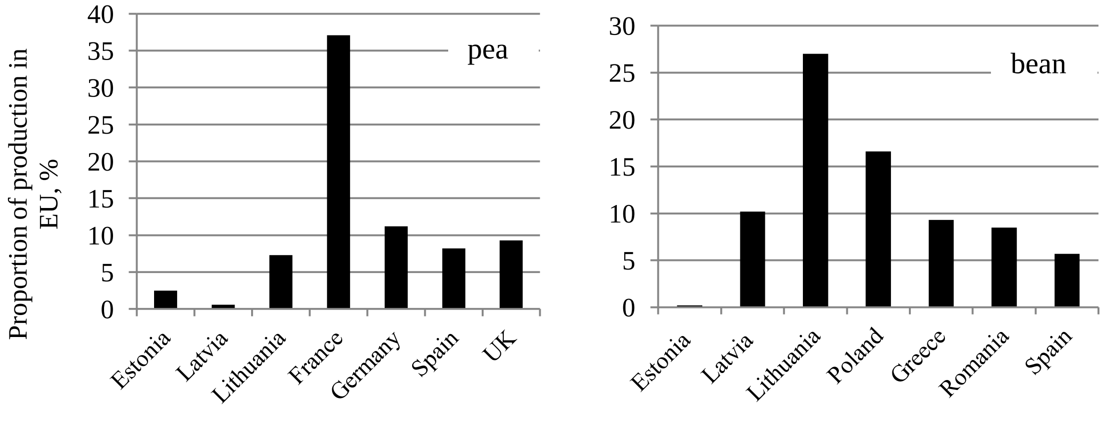

Fig. 1. Proportion of pea and bean (dry) production (%) of some countries in EU in 2014 (FAOSTAT).

Pulses or grain legumes are mostly annual herbaceous plants like beans, lentils, lupins, peas and peanuts – legumes that have 1 – 12 seeds in the pod. Dry seeds are highly valuable source of protein and fibre.

There was total of 1379 thousand tons of peas and 231 thousand tons of beans produced in Europe in 2014. The largest producer of peas was France (37.1%), followed by Germany (11.2%) (Fig. 1). Lithuania contributed the most (7.3% of the total EU production) of peas among Baltic countries. Pea production has decreased significantly from 5.4 million tons to 3 million tons during 2001 – 2013.

The largest producer of beans was Lithuania (27%), followed by Poland (16.6%) (Fig. 1). Bean production decreased in the EU from 610 thousand of tons to 510 thousand tons in 2001 – 2013. Pea and bean production has increased in Estonia during the recent years (Fig. 2). Pea production has increased six times over a twelve year period. Bean production was minimal in 2002 – 2012, but the production has been increasing recently.

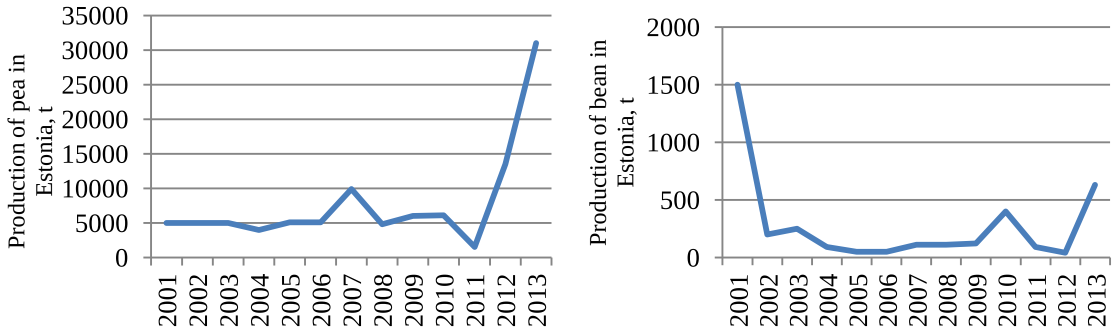

Fig. 2. Production of pea and beans (tons) in Estonia in 2001–2013 (FAOSTAT).

Legumes are researched and bred in the Estonian Plant Production Institute and Estonian University of Life Sciences. There is a bean cultivar 'Jõgeva' with the yield of 3.267 t ha^{-1}. Better yielding cultivars are needed, as for example in Germany the average yield is more than 4 t ha^{-1}. However, the thousand seed weight is high in cultivar 'Jõgeva' – 775 g. In 2008, a five field long-term field crop rotation experiment comparing organic and conventional growing systems was established at the Estonian University of Life Sciences (58°22' N, 26°40' E*)*. During the crop cycle period five different crops followed each other in the order: barley (*Hordeum vulgare* L.) with undersown red clover, red clover (*Trifolium pratense* L.), winter wheat (*Triticum aestivum* L.), pea (*Pisum sativum* L.), potato (*Solanum tuberosum* L.). So far the focus has been on potatoes and wheat, but there is a need to strengthen the research on peas.

To highlight the importance of legumes in crop rotation, there is a call within the EU program Horizon 2020. Projects are expected to cover both conventional and organic sectors. They will develop transition paths that aim to lift identified constraints on sustainable legume-based agri-feed and food chains. Activities will involve transdisciplinary research, including the input from social sciences and the humanities, to engage actors in developing the production and use of legumes, including market aspects. Proposals should fall under the concept of the 'multi-actor approach' and ensure adequate involvement of the farming sector.

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LEGUMES FOR SUSTAINABILITY OF AGROECOSYSTEMS

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Legumes are essential tool for adjustment of nutrient cycling in organic and other farming systems, for improvement of subsequent crops grain quality, soil productivity, crop rotation health, farm viability and sustainability. Legumes growing and potential applications in farming systems are numerous, including species, varieties, cultivation techniques, purpose of use, frequency in crop rotation etc. The capacity of legumes to fix atmospheric N and make it available to non-fixing plants has made them as fertility building crops. This ecological service of legumes can be provided through incorporation of legumes in crop rotation as main crop or pre-crop, as catch crop or as intercrop and various combinations could be in crop rotations in different environmental conditions and in farms with different purposes. Despite the benefits and increasing areas of legumes, their management is complicated and use in crop rotations mostly is insufficient (Doltra, Olesen, 2013; Nemecek et al., 2015; Magrini et al., 2016; Preisel et al., 2015). This paper aims to discuss research on legumes benefits and results of research through a number of recent experiments in Lithuanian Research Centre of Agriculture and Forestry and combine knowledge of previous studies.

Grain legumes: pea, lupine, faba bean, vetch and spring wheat were sown as intercrops and sole crops and were grown for grain organically in 2007 – 2009 on a loamy *Endocalcari-Ephypogleyic Cambisol* in Dotnuva (55˚24' N, 23˚50' E), Lithuania. The influence of legume and manure pellets on spring cereals productivity were investigated on a loamy soil at Dotnuva, and on a heavy loam *Cambisol* at the Joniškėlis Experimental Station (56º21' N, 24º10' E). Oats and spring wheat were grown respectively, in 2013 and 2014. Oats were sown sole, with undersowing of red clover or in mixture with pea. To some treatments organic manure pellets (2 t ha^{-1} or 60 kg N ha^{-1}) were used. In the second year of experiment spring wheat with fertilizing of organic manure pellets or without it was sown. In 2015, barley was grown. In 2015, we started experiments with the soyabean on a loamy soil in Dotnuva. Sowing date, row distances and other agrotechnological measures will be tested. In our Research Centre, even more research was conducted with legumes, which is not discussed in the summary, but will be interpreted during presentation.

Mixing species in cropping systems may lead to a range of benefits. First of all, it can act as a short-term measure and increase the yield and quality. The productivity of spring wheat in intercrops depended on the species of grain legume; however, the results varied over the experimental years due to different weather conditions (Table 1). The concentration of crude protein was higher in grain yield, when spring wheat had been grown in intercrops.

Table 1

The grain yield of legume grown as sole and intercrops with spring wheat

Treatment	Grain yield, kg ha^{-1}			Crude protein, g kg^{-1}		
	2007	2008	2009	2007	2008	2009
Wheat	4132	2811	2496	115	101	122
Pea	3370	1107	2626	218	237	236
Lupin	2731	469	1323	236	239	302
Bean	3218	1011	1727	285	281	296
Vetch	2265	2214	1165	355	282	305
Wheat/pea	3876	2509	2406	124	133	132
Wheat/lupin	4037	1632	2654	120	109	134
Wheat/bean	3493	2668	2348	143	123	139
Wheat/vetch	4387	2645	2982	155	154	167
$LSD_{0.5}$	246.7	446.5	382.3	15.5	7.0	7.57

The most common management factors that can contribute to support plant productivity and soil fertility in organic system is legumes. However, using only the nitrogen fixed by legumes, it is not easy to meet the nitrogen needs of other crops at the right time. It is therefore interesting to look at combinations of pulses and newer forms of organic fertilizer as cow manure pellets. Grain yield of spring wheat was affected by using of manure pellets and biomass of incorporated red clover in both locations (Table 2). The benefit of nitrogen from manure pellets or red clover was reduced by spread of weeds.

Table 2

Effect of legumes and manure pellets on spring cereals grain yield, kg ha^{-1}

Treatment		Oats, 2013		Spring wheat, 2014		Barley, 2015	
		Joniškėlis	Dotnuva	Joniškėlis	Dotnuva	Joniškėlis	Dotnuva
O	SW	5669 bc	3472 def	3767 ab	2643 ab	2491 abc	2336 abc
O	SW+CMP	6033 cde	3348 cdef	4363 cd	2749 ab	2948 de	2568 abc
O+CMP	SW	6322 de	2717 ab	4281 bcd	2622 ab	2683 bcd	2862 c
O+CMP	SW+ CMP	6480 e	3482 def	4616 d	2700 ab	3241 e	2851 bc
O+CMP	SW+WC	6322 de	3114 bcd	4162 bcd	2778 ab	5016 f	2804 abc
O+RC	SW	5988 cde	3837 f	4420 cd	2764 ab	2456 bcd	2425 abc
O+RC	SW+CMP	6154 cde	3772 ef	4482 cd	2820 ab	2767 cd	2536 abc
MOP	SW	5294 b	2856 abc	4323 bcd	2705 ab	2536 abc	2306 a
P	SW	3051 a	2525 a	4308 bcd	2700 ab	2286 a	2432 abc
RC	SW	0	0	3603 a	3023 b	2405 ab	2590 abc
Mean		5701	3236	4232	2750	2883	2571

O–Oats, RC–Red clover, MOP– mixture of oats and peas, P–peas, SW– Spring wheat , WC–white clover, CMP–cattle manure pellets (2 t ha^{-1} or 60 kg N ha^{-1}). Different letters indicate significant differences at $p < 0.05$.

Sowing time affected the soy yields (Table 3). Soybean yielded better when sown in later sowing time. Inoculated soybean seeds produced a bigger seeds than not inoculated. Row spacing on seed yield had little effect.

Table 3

Effect of sowing date and row distances on soya production

Treatments			Seed yield, kg ha^{-1}	Weight of 1000 seeds, g	Plant m^{-2}	Pods m^{-2}	Seeds in pod
Sowing date	Non or inoculated seeds	Row distances					
Early	Non	50 cm	2301	143	62	472	2.3
	Ino		2608	151	71	511	2.6
	Non	25 cm	2525	140	85	536	2.0
	Ino		2858	155	86	552	2.1
Late	Non	50 cm	2423	144	64	482	2.4
	Ino		2745	152	66	502	2.6
	Non	25 cm	2934	148	78	545	2.2
	Ino		2978	151	75	551	2.4
$LSD_{0.5}$			251	0.05	5.8	51	0.2

Our results indicate that the productivity and the quality can be improved by the use of legumes and in combination with other management factors, but for more reliable conclusions more experiments are needed.

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THE IMPLEMENTATION OF THE NATIONAL RESEARCH PRGOGRAMME AGROBIORES (2014–2017)

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The aim of the National Research Programme "Agricultural Resources for Sustainable Production of Qualitative and Healthy Foods in Latvia" (AgroBioRes) – development of the knowledge base for the sustainable use of agricultural technologies in quality food raw material production, processing, and control of raw materials and foods in Latvia, in order to provide consumers with healthy and safe food products of local origin, promoting agriculture and food sector growth and competitiveness.

Within the programme for achieving set aims and fulfilment of the tasks, five mutually interlinked projects are established.

Project No. 1 Sustainable use of soil resources and abatement of fertilisation risks (SOIL) – leader Dr. habil. agr. Antons Ruza, executors Faculty of Agriculture and Faculty of Rural Engineering at Latvia University of Agriculture (LLU).

Project No. 2 Biological processes influencing sustainable fruit growing and widening possibilities for use of by-products (FRUITS) – Ph. D. Inga Morocko-Bicevska, executor Institute of Horticulture, former Latvia State Institute of Fruit-Growing.

Project No. 3 Genetic research on local dairy cows and pigs economically important traits to produce quality food products, development and approbation of natural origin feed components for animals' nutrition (LIVESTOCK) – Dr. agr. Daina Jonkus, executor Faculty of Agriculture and Faculty of Veterinary Medicine at LLU.

Project No. 4 Sustainable use of local agricultural resources for qualitative and healthy food product development (FOOD) – Dr. sc. ing. Tatjana Kince, executors Faculty of Food Technology (LLU), Stende and Priekuļi research centres of Institute of Agricultural Resources and Economics (former State Stende Cereal Breeding Institute and former State Priekuli Plant Breeding Institute).

Project No. 5 (RISKS) Resistance of microorganisms and other biological and chemical risks research procedures development and application in the food chain (RISKS) – Dr. med. vet., Ph. D. Aivars Berzins, executor Institute of Food Safety, Animal Health and Environment „BIOR".

Projects supplement each other because they cover all food production chain "from stable to table", starting from sustainable production of agricultural products in agriculture, fruit-growing, and livestock farming. Further development of raw material processing is drawing attention to new niche products and utilization of food production by-products, and evaluation of biological and chemical hazards in whole chain of production and processing.

In the project "SOIL" activities are carried out to reach the aims: development of the knowledge basis for fertilization planning and mitigation of eventual nitrogen and phosphorus losses from agricultural land; study of the impact of main technologies used for field crop cultivation on soil sustainability and biological diversity. Fertilisation trials including soil $N_{min.}$ ($N–NO_3$ + $N–NH_4$) monitoring have been realised in 5 geographic locations all together in 18 plots. Soil sampling was done in three depths (0–30; 30–60 and 60–90 cm) monthly during the vegetation. Detailed investigation of soil physical and chemical properties was done. These plots will be used also for the following years investigations; therefore, obtained data will be useful to model the nitrogen and phosphorous turnover in the soil. In three locations soil data is possible to combine with agricultural run-off measurements (separate project); therefore, complex data set is expected to be obtained. Evaluation of impact of technologies (soil tillage and crop sequence) on the possibilities for sustainable soil use and biodiversity conservation was continued. Microbial biomass increased in plots without soil inversion in comparison with conventional tillage with soil inversion. The activity of cellulose microbial degradation decreased in the plots without crop rotation. *Oculimacula* spp. (36%) and *Microdochium nivale* (21%) were dominant causal agents of wheat stem base and root rot. Obtained results confirmed variability of pathogen's spectrum and probable, pathogens, which were considered as insignificant become harmful. Elevated level of mycotoxin in wheat grains was determined in plots with continuous sowings and reduced soil tillage. Different species of *Fusarium* were found in maize grains and peas as well as, risk of mycotoxins accumulation in grains and seeds increased under conditions of intensive crop production. The ground beetles and possibly also rove beetles are important indicators of many agro-ecological factors. The field method (a grid of 24 sample plots) was acknowledged as useful for studies of ground beetles inhabiting field crops. Different natural and semi-natural landscape elements provide 32.8% of ground beetle species recognized in the studied wheat fields. The pre-crop significantly affected species structure and biodiversity of rove beetles, but the intensity of soil tillage did not affect those parameters.

Two aims are set for the project "FRUIT" – (1) development of scientific knowledge on important biological factors affecting fruit and berry quality for ensuring production and nutritional quality and (2) development of processing technologies for widening possibilities for the use of fruits and by-products and diversification of the market. The project focuses on the detection of occurrence of most important diseases affecting apple and pear fruits, identification of their causal agents, and providing scientific data for improvement of the control; elucidation of genetic and biological aspects of fruit tree and pathogenic fungi interactions in the orchard and during the storage, and providing scientific knowledge for improvement of the control; improvement of detection methods of fruit harvesting time, assessing fruit ripening process impact on storage period extension, combining with 1-MCP treatment for ensuring of fruit quality during the storage; evaluation of Latvian local selection outdoor grapevines for purposeful maintenance and for widening of possibilities of utilization; studies of chemical content (stilbenes, e.g. resveratrol, phenolic acids, procyanidins etc.) in Latvian local selection grapes for widening of utilization; development of innovative products containing biologically active substances using fruit and berry growing and processing by-products (e.g. shoots, fruitlets, seeds).

The project "LIVESTOCK" deals with explanation of the genetic suitability of local breeds of dairy cattle and swine for high-quality food (cheese and meat) production and is working out recommendations for a new feed component of natural origin (containing additives containing bacteriocins, prebiotics and symbiotics) for farm animals (pigs and cows) to improve composition of micro flora in the digestive canal, for disease prevention and treatment that will increase animal productivity and create prerequisites for high quality raw food production, safe for human consumption.

Within the project "FOOD" wide range of raw materials have been evaluated – diversity of barley and oats, rye and triticale grain, and potato. The project deals with the development of new food products for special task groups (gluten-free, diabetes prevention etc.) by using of gluten-free croppers (buckwheat etc.) and legumes additionally diversifying of existing assortment; development of solutions for the use of agriculture and food production by-products and its biologically active compounds application in food with elevated value; determination of the obtained products sensory properties, nutrients (carbohydrates, dietary fibre, proteins, amino acids, vitamins, mineral substances, carotenoids, phenols etc.), investigation of textural properties (hardness, extensibility etc.), physical parameters (moisture, colour etc.) and microstructure changes during processing and storage; evaluation of new and/or improved food products shelf-life by identification and assessing of possible microbiological contamination risks, as well as performing microbiological analysis; determination of optimal shelf-life conditions for developed food products by using the latest packaging materials and technologies.

The main activities carried out in the project "RISKS" deal with studying and identifying the occurrence of resistant microorganisms in farm animals and food chain, and develop new knowledge about development of antimicrobial resistance (AMR) mechanisms; investigation of the correlation between AMR and veterinary drug usage in animal feed and medicine and inform professionals and the public about the resistance containment and opportunities; development and implementation of modern diagnostic and analytical methods that will support research on food raw materials, products and environment, gaining knowledge on risks to humans.

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More detailed information on the National Research Programme AgroBioRes can be found at www.agrobiores.lv.

FERTILISER NORMATIVES – ADJUSTMENT FOR LOCAL SOIL CONDITIONS

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Following requirements of EU Nitrate directive and Code of Good Agricultural Practice, there are several guides for manure application and fertiliser use especially those containing nitrogen in Latvia. Maximum permissible amount of nitrogen used by manure and by mineral fertilisers, recommended nitrogen rates for different crops, advises for fertiliser planning and application etc. are examples of such regulations (Lauku kultūraugu …, 2013; Regulation Regarding …, 2014). In general, these regulations are quite well accepted by farmers and used in practical farming activities. The only shortcoming of these activities – soils and farming methods are very variable and therefore different adjustments might be necessary for the standard guidelines to keep at least nitrogen management in a good shape. Also, a part of farmers is more and more arguing because they are dissatisfied with regulations which limit their attempts to intensify crop production. They are using high demanding varieties or hybrids, crop monitoring systems, site-specific fertiliser application equipment etc. high-tech solutions giving possibility for more accurate fertiliser use and more effective nutrient turnover. Therefore, standard schemes or country averages not always fit or not always are reasonable for these situations.

To satisfy the needs of intensive farming and to monitor environmental risks, a new project „Sustainable use of soil resources and abatement of fertilisation risks” was started in 2014, which is related to the Latvia State Research Program for the time period up to 2017. The objectives of the first chapter of the project are:

- assessment of soil and water pollution in agriculture to evaluate the leakage of nitrogen and phosphorus from different soils and depending on fertilizer application rates;
- development of the propositions for nutrient application rates taking into consideration leaching risks and soil water retention capacity;
- determination of nitrogen losses and its apparent recovery from used fertilizers depending on different methods of application and incorporation.

The novelty of this project includes mainly the following aspects. Firstly, obtained results of field trials and soil investigations are combined with those, obtained from the subsurface water quality measurements. Nitrogen and phosphorous concentration in subsurface water from the plots of experiments gives more detailed information about environmental risks of fertiliser use and could be combined together with traditional methods of assessment of fertiliser use efficiency.

Secondly, more detailed attention is paid to soil physical properties. Leaching risks for mobile nutrients, e.g. mineral nitrogen mostly depends on such parameters like soil porosity, bulk density, structure, infiltration rate, water holding capacity. These parameters not always were tested before, when fertiliser experiments were carried out.

Methods of soil tillage, like traditional ploughing and reduced plough-less tillage are the next factors due to the fact that many farmers more and more use the last alternative in their fields. Reduced tillage together with postharvest residues incorporation may significantly change the pattern of nitrogen transformations due to the microbiological activity and also due to the change of soil physical properties.

Assessment methods for evaluation of soil nitrogen pool include the total nitrogen. Although the total nitrogen reserves are quite stable and many factors influence its transformations and release in the plant available forms, however this pool is a starting point for the following changes. One example is so called organic soils – soils rich with organic matter and subsequently with the total nitrogen. In such soils special attention should be paid to the use of nitrogen containing fertilisers.

Monitoring of mineral nitrogen content in the soil and consideration of these amounts in fertilisation planning and application of nitrogen containing fertilisers and manures. This aspect is quite difficult due to the variability of soils and farming practice, meteorological conditions, biological activity etc. Actually, on the one hand, this is a finishing point of soil nitrogen transformations, but at the same time it is a starting point for plant nitrogen uptake. If we are not able to assess this parameter realistically, recommendations for nitrogen fertiliser use will be only approximation.

All in all, this research should end with the updated and improved fertiliser normatives providing a possibility for better differentiation of fertiliser rates and assessment of feasible nitrogen excess if high amounts are used. By this we will try to avoid the situation when fertiliser recommendations are fixed for somewhat average farming level, and farmers using more advanced technologies and producing high yields year by year are limited by certain regulations.

Simultaneously with the fate of nitrogen in the system: soil – crops – water, also attention is paid to phosphorous. Phosphates of course are more persistent in the soil, but anyway, erosion, surface run-of and other factors may cause its transport up to waterbodies. Therefore, monitoring results of phosphorous concentration in surface and subsurface waters is combined together with specific soil properties (including physical) and fertiliser use.

Taking into consideration relatively large scope of objectives, several tasks, which are rather complicated and time and money consuming, might be useful topic for some cooperation. Nitrogen and phosphorous are nutrients which will be under the focus permanently and we will expect stricter and stricter regulations on this area. Soil and climate conditions as well as farming practice in the Baltic States are more or less similar. Therefore, the general conception about the interpretation of several aspects and also evaluation of soil nitrogen status, crop requirements, modelling of nitrogen transformations and dynamics, potential losses etc. also could be developed together.

Acknowledgements

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THE INFLUENCE OF TILLAGE ON SOIL MICROBIOLOGICAL ACTIVITY

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Soil tillage practices affect the soil microbial community in various ways with possible consequences for nitrogen (N) losses, plant growth, and soil organic carbon (C) decomposition. On the other hand, soil microorganisms are involved in biochemical processes that include the decomposition of plant residues and the transformations of organic matter, affect the mineralization of plant available nutrients, and influence the efficiency of nutrient cycles (Jackson et al., 2012). The soil microbial composition and activity determine its potential for substrate catalysis since most of the processes occurring in soil are microbe-mediated and carried out by enzymes. The process of soil aggregation, which is an important regulator of organic matter dynamics and soil fertility, is expected to be closely related to changes in microbial communities (Anderson, 2003; Tiemann et al., 2015).

The present study was aimed at estimating the effect of conventional and minimum tillage systems on soil microbiological activity. The long term trials were established in the experimental fields of the Latvia University of Agriculture. The crops were cultivated both in a monoculture (winter wheat) and using crop rotation (winter wheat–rape; winter wheat–rape–faba bean). Soil samples were taken from two soil layers (at the depths of 0–10 cm and 10–20 cm) using an auger with a 2-cm diameter. Field-moist samples were stored in plastic bags at 4 °C for soil biological activity analysis. Soil respiration intensity was measured by changes of carbon dioxide, while microbial biomass was calculated according to substrate that induced respiration. Soil enzymatic activity was assessed by oxidative enzymes (dehydrogenase) activity and fluorescein diacetate (FDA) hydrolysis, which characterize complex activity of some hydrolytic enzymes (esterases, proteases, lipases) and cellulose degradation activity was determined by using linen pieces.

The obtained data show that weather conditions significantly affected the activity of microorganisms. Despite the fact that the response of soil microbial biomass to tillage varied, soil microorganisms' biomass is less affected by tillage system in comparison with soil microorganisms' activity. Minimum tillage leaves a significant amount of plant residues in the soil surface. Although the upper soil layer has a higher potential of microbiological activity, the minimum soil tillage does not provide an even decomposition of plant residues. The microbiological activity in the deeper soil (10 – 20 cm) layer fluctuated not so significantly as in the upper soil layer.

The research was supported by the State research programme "Agricultural Resources for Sustainable Production of Qualitative and Healthy Foods in Latvia", Project No. 1 Sustainable use of soil resources and abatement of fertilisation risks (SOIL).

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INFLUENCE OF MINIMAL SOIL TILLAGE AND CROP ROTATION ON WEED POPULATION IN CROPS

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Soil tillage is one of the main methods to reduce weed pressure. Ordinary, soil tillage is the most powerful regulator of the weed flora on arable land, however, reduced tillage leads to increased numbers and changed proportions of weed species, some of which become increasingly problematic if not controlled by herbicides (Hakanson, 2003; Wozniak, 2011). Weed population density may be markedly reduced using crop rotation strategy (Liebman, Davis, 2000).

The objective of the present trial was to investigate the impact of soil tillage systems on weed incidence in the crop rotations with different crop sequence.

A long-term field experiment was established at the Study and Research Farm “Peterlauki” of the Latvia University of Agriculture in 2008 (55 30’ 7” N; 23 41’ 6” E). The soil of the experimental site is *Cambic Calcisoil* (*Endogleyc*, *Bathyruptic*, *Episiltic*), sandy loam. Organic matter – 21.0 g kg^{-1}, K_2O – 295 mg kg^{-1}, P_2O_5 – 148 mg kg^{-1}, pH KCl – 7.1.

Two tillage systems: 1. conventional tillage (CT) plough tillage at the depth 0.22–0.23 m with mouldboard plough, and 2. reduced tillage (RT) – shallow tillage at the depth 0.10–0.12 m with disc harrow were compared in three different crop rotations: 1) spring wheat – winter wheat – winter wheat – spring wheat – winter wheat; 2) spring oilseed rape – winter wheat – winter oilseed rape – spring barley - spring oilseed rape; 3) spring barley – winter barley - winter oilseed rape – spring wheat – field beans. Weeds were counted before the harvest of crops. Herbicides registered in Latvia were used, chosen according to weed species composition, and abundance. Spray applications were made according to the experimental design.

The paper presents the results of studies during the time period 2011 – 2015.

Annual weeds were the most important group of weeds in all treatments. During the five years of investigation, comparing the RT and CT systems, the total number of weeds on average during 2011 – 2015 in the 1; 2 and 3 crop rotations were respectively: 1) 56.6 and 21.4, 2) 43 and 16.4, 3) 25.0 and 25.0 plants m^{-2}, perennial weeds: 1) 9.8 and 3.2; 2) 7.2 and 1.2; 3) 11.6 and 1.0 plants m^{-2}. Reduced soil tillage significantly increased incidence of perennial weeds ($P < 0.05$), but influence of crop rotation was not essential. Reduced soil tillage increased the total number of weeds by 50%.

Reduced soil tillage significantly increased the incidence of perennial weeds, but influence of crop rotation was not essential.

Research was supported by a grant from the Ministry of Agriculture Influence of minimal soil tillage on its fertility maintenance, development and distribution of pests as well as crops’ yield and quality in resowings.

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EFFECT OF SOIL TILLAGE AND CROP ROTATION ON THE DEVELOPMENT OF WHEAT DISEASES

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Winter wheat is one of the most beneficial and widely sown crop in Latvia. Crop rotation and soil ploughing have been reported as main factors that influenced development of wheat diseases; however, investigations over the world demonstrate importance of other factors as well. Conventional ploughing in general decrease development of wheat stem base (crown) and root rot, but in some cases opposite results were observed (Matusinsky et al., 2009; Fernandez et al., 2011; Bankina et al., 2013). Severity of tan spot was significantly increased under reduced tillage, especially in continuous wheat sowings (Jørgensen, Olsen, 2007; Bankina et al., 2015).

The aim of this study is to clarify effect of soil tillage and crop rotation schemes on the development of wheat crown rot and leaf diseases.

Long-term experimental field plots were established at the Study and Research farm "Peterlauki" of the Latvia University of Agriculture in the autumn of 2008. In this study, the development of diseases during 2012 – 2015 was evaluated. All wheat plots (12 plots every year) were arranged as two factors: A – soil tillage (1 – plough tillage with a mouldboard plough; 2 – shallow tillage with a disc harrow); B – crop sequence (1 – continuous wheat (W – W); 2 – short crop rotation, including only wheat and oilseed rape (W – OR); 3 – crop sequence, including barley and faba beans in 2014 (CS).

The incidence of the complex of stem base diseases (crown and root rot) was determined after wheat harvesting. Leaf diseases were assessed weekly. AUDPC (area under diseases progress curve) was calculated to express impact of disease during the whole season of vegetation. Causal agents of stem base and root rot were identified by mycological methods, but the results were confirmed by molecular analyses.

All agronomic measures were applied uniformly, according to the requirements of agronomic practice in Central Latvia in the vegetation season. Fungicides against stem-base diseases were not used, but foliar fungicides (epoxiconazole, 84 g L^{-1}, and fenpropimorph, 150 g L^{-1}, 1.5 L ha^{-1}) were sprayed across all wheat plots at the heading stage. For the statistical analyses of the incidence of crown and root rot, a two-way analysis of variance (ANOVA) was performed.

Level of crown and root rot fluctuated significantly depending on a year. The method of soil tillage did not affect development of this disease, but lack of crop rotation increased incidence of crown and root rot ($p = 0.04$); however, this influence was expressed more clearly in the fields without ploughing (Fig. 1).

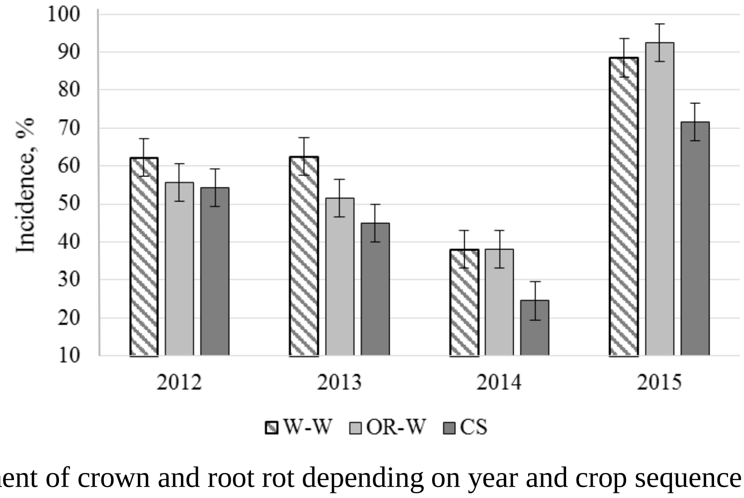

Fig. 1. Development of crown and root rot depending on year and crop sequence under soil tillage without ploughing: W-W – only wheat; W-OR – wheat and oilseed rape; CS – other crops (barley, faba beans were included).

All together 5332 isolates were obtained from symptomatic plants. The dominated pathogen's genera were *Oculimacula* and *Fusarium*/*Gibberella*. Both species of *Oculimacula* spp. (*O. yallundae* and *O. acuformis*) were determined. *Bipolaris sorokiniana*, *Rhizoctonia* spp., *Gaeumannomyces graminis* were found only in some cases. *G. avenacea*, *G. tricincta* and *F. culmorum* were identified more frequently, but relative density of *Gibberella zeae* was low, only 0.6%. Agrotechnical measurements did not influence spectrum of pathogens significantly.

Tan spot, caused by *Pyrenophora tritici-repentis* was the dominated disease, Septoria leaf blotch, caused by *Zymoseptoria tritici* was found every year as well, but incidence of other leaf diseases was low, severity did not reach 2%.

Crop sequence and soil tillage method essentially affected level of tan spot, $p<0.001$ and $p<0.01$ respectively (Fig. 2).

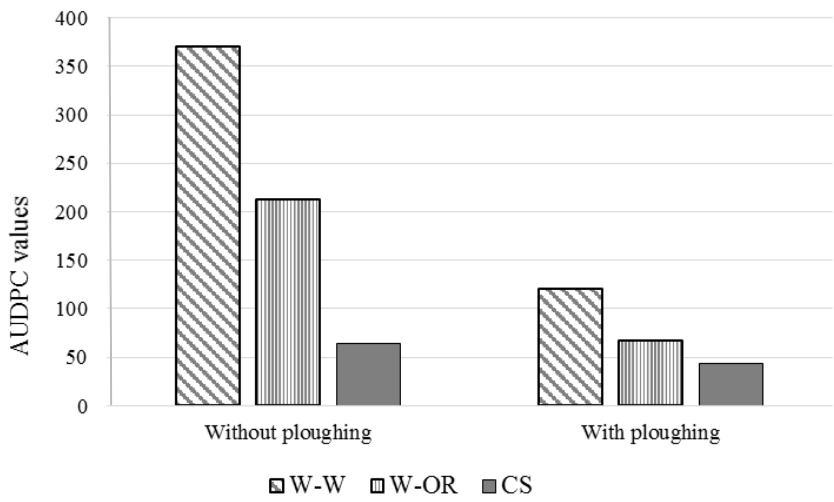

Fig. 2. Development of tan spot depending on soil tillage and crop sequence, average 2012 – 2015: W-W – only wheat; W-OR – wheat and oilseed rape; CS – other crops (barley, faba beans were included).

Continuous wheat sowings are the main risk factor, which promote development of tan spot, but ploughing can mitigate this influence.

Ploughing and crop rotation can significantly decrease the level of some diseases, but the effect is dependent on a year and causal agent's biological peculiarities.

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THE PHENOLOGY OF GROUND BEETLES (CARABIDAE) IN DIFFERENTLY MANAGED WINTER WHEAT FIELDS

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Ground beetles (Carabidae) are species-rich family of insects. Mostly, these are epigeic beetles inhabiting different terrestrial habitats including agricultural land. In agriculture, ground beetles are beneficial organisms as predators of different crop pests and weed seeds. In Latvia, only sporadic studies have been carried out on these issues, thus there is lack of knowledge on ecology of ground beetles inhabiting different crops. Objective of this study is to analyse phenology of ground beetles species community inhabiting winter wheat (*Triticum aestivum*) fields with differently tilled soil and different crop rotations.

The research was carried out in Latvia University of Agriculture Research and Study Farm 'Peterlauki' (56^{o}30'39.38''N; 23^{o}41'30.15''E) during 2012 and 2013. A grid of 24 sample plots (0.25 ha; 30 x 85 m), created in 2009, was used for the study. The main soil treatment for each 12 plots was ploughing (0.22-0.23 m) and non-inverse tillage (0.10-0.11 m) with a disc harrow. In each season, six ploughed and six harrowed sample plots were sown with winter wheat (variety 'Zentos'), and these sample plots were used for this study. Other field crops were sowed in other sample plots. Spring rapeseed (*Brassica napus*), spring and winter wheat were pre-crops in winter wheat sample plots in 2012, but in 2013, winter wheat and spring rapeseed were used as pre-crops. It formed six and four combinations of both agro-ecological factors – soil tillage and pre-crop – each year, correspondingly. Plastic glasses (200 ml), half filled with 4-5% vinegar, were used as pitfall traps for collecting of ground beetles. Ten traps were placed in 30 m long cornerwise transect in each sample plot. Exposition of them started in the spring (17 April 2012 and 23 April 2013), but ended a few days before harvesting of winter wheat (31 July 2012 and 30 July 2013). The traps were emptied every seven days. Species of beetles were identified after Freude et al. (2004), but the dominance structure of ground beetle species was calculated according to Engelmann (1978).

Results of the study show that soil tillage and crop rotation affect species community of ground beetles inhabiting winter wheat fields. This effect was evident during the whole growing season. At the beginning of vegetation season, mostly different *Bembidion* species and *Poecilus cupreus* noticeably dominated over other species. These are typical spring-active ground beetles. At this time, species community was significantly less balanced in ploughed sample plots than in non-inverse tilled ones. This state lasted until June when summer-active ground beetles, e.g., *Harpalus rufipes*, *Pterostichus melanarius*, *P. niger* and *Loricera pilicornis* started to appear as dominant or subdominant species. This situation was particularly evident in 2013. *Pterostichus melanarius* was less abundant in sample plots with rapeseed as pre-crop. Especially in 2012, this species was almost absent from these plots. It corresponds with other studies showing that *P. melanarius* is conservative species which does not like crop rotation (Lövei, 1984). Other species *Amara plebeja* was noticeably abundant in non-inverse tilled sample plots without a real long-term plant rotation – spring wheat pre-crop in 2012, but winter wheat – in 2013. Comparably more seeds producing weeds were observed in these sample plots than in other ones, but *A. plebeja* is a well-known seed predator of different herbaceous plants. It explains why this species was the most dominant (in 2012) or subdominant (in 2013) ground beetle in sample plots mentioned previously, but scarce in other sample plots.

The research was supported by National Research Programme "Agricultural Resources for Sustainable Production of Qualitative and Healthy Foods in Latvia", the project "Sustainable use of soil resources and abatement of fertilisation risks".

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MANAGEMENT OF BUMBLEBEES TO DELIVER BIOCONTROL AGENTS IN OPEN FIELD CONDITIONS

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Strawberry *Fragaria* × *ananassa* is a valued fruit crop grown worldwide, but diseases such as a grey mould *Botrytis cinerea* frequently limit the yield. The majority of the grey mould infection on fruits originates from flowering period (Williamson et al., 2007). The use of foraging bees as disseminators of microbial control agents (MCAs) to flowers is known as entomovector technology (Mommaerts, Smagghe, 2011). Multiple researchers have shown that bumblebees can efficiently vector MCAs (Peng et al., 1992; Reeh et al., 2014); however, most of studies have been conducted under greenhouse conditions (Kevan et al., 2003; Mommaerts et al., 2011). The aim of this study was to investigate to what extent a bumblebees *Bombus terrestris* visit strawberry flowers and whether it can suppress *Botrytis cinerea* in open field conditions where many competing plant species are flowering simultaneously.

Bumblebee triple hives were placed near strawberry fields in Southern Estonia (Rõhu 0.5 ha and Polli 2 ha) in 2012 – 2014. Each hive had a special dispenser attached containing the biofungicide Prestop-Mix. Two treatments were established: bee-delivered Prestop-Mix treatment and isolated control. To estimate the effect of the bumblebee delivered Prestop Mix on grey mould infection rate, the healthy and *Botrytis*-infected berries were counted. Pollen pellets from homing forager bumblebees were gathered (n = 960) and identified.

The study showed that bumblebee gathered pollen contained on average 20 – 25% strawberry pollen and 1/3 of them visited mostly strawberry during one foraging trip. The rate of strawberry infection by grey mould was lower on the plots that were visited by bumblebees compared to isolated control plots: in 2012 – 65.3 % (p = 0.007); in 2013 – 37.3% (p = 0.043) and in 2014 – 4.7% (p = 0.72). This study provides strong evidence that bumblebees can vector a MCA to reduce significant *B. cinerea* incidence not only in greenhouse strawberries, but also in open field conditions where the landscape is heterogeneous with many competing flowers.

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EARTHWORM DENSITY IN SPRING OILSEED RAPE CROP IN ORGANIC FARMING SYSTEM

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Earthworms play an important role in soil fertility and crop productivity (Brown et al., 2004). The number of earthworms depends on many environmental and agrotechnical factors, including use of different weed control methods. Smothering is the most common method of weed control in oilseed rape crops in organic farms. However, weed smothering ability of oilseed rape is low during rosette stage. Mechanical weed control is practiced in organic farms and can significantly reduce weed density (Praczyk, 2005). Thermal weed control method with water steam can be used in organic farms as well (Sirvydas et al., 2009). It is nessecarry to investigate the effectiveness of plant bio-activators in organically grown crops. The objective of this study is to assess the impact of different weed control methods and bio-activators on earthworm density in spring oilseed rape crop in an organic farming system.

The field experiment was carried-out at the Experimental Station of Aleksandras Stulginskis University in 2013 and 2014. The soil of experimental field was *Calc(ar)i-Endohypogleyic Luvisol*. Experimental treatments: factor A – non-chemical weed control methods: 1) TWC – thermal (water steam), 2) MWC – mechanical (inter-row loosening), 3) SMT – smothering (self-regulation); factor B – plant bio-activators: 1) no application and 2) with application. TWC and MWC were applied in oilseed rape crop cultivated at a wide row spacing of 48 cm. Oilseed rape was cultivated at an inter-row spacing of 12.0 cm in plots where smothering was used for weed control.

The highest earthworm number in the soil was estimated in plots where the weed control method smoothering was applied with and without bio-activators (Fig.). Thermal weed control in plots with bio-activators significantly ($p \leq 0.01$) decreased earthworm number compared with the weed control method smoothering in plots with bioactivators in 2013 and 2014. The earthworm number and mass in the soil depended on the meteorological conditions during vegetation period, especially on humidity. Significantly lower earthworm density in 2014 compared with 2013 was determined by the lack of soil moisture. The significantly higher mass of earthworms was established in plots with plant bio-activators.

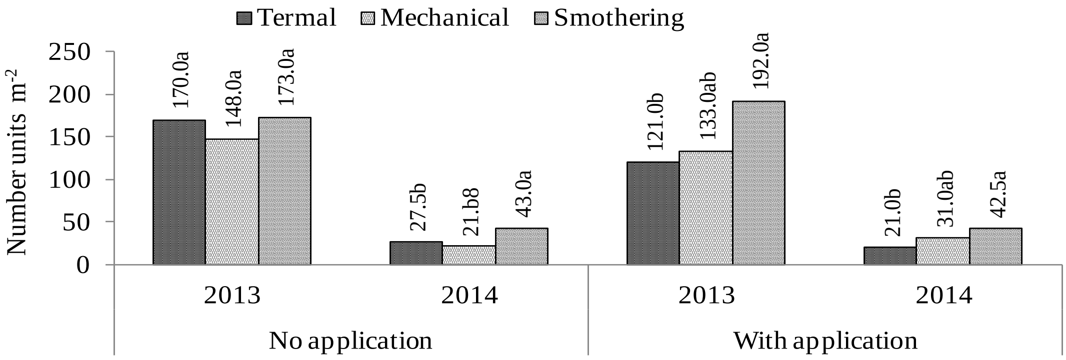

Fig. Earthworm number in the soil in plots with different weed control methods and with or without application of plant bio-activators. Means not sharing a common letter (a, b, c) are significantly different ($p < 0.05$).

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EFFECT OF MEDIUM COMPOSITION ON MISCANTHUS × GIGANTEUS REGENERATION COMPETENCE

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Miscanthus × *giganteus* is a potential dedicated bioenergy crop due to its high biomass yield (Heaton et al., 2004), conversion of solar radiation to biomass (Beale et al., 1996). *Miscanthus* × *giganteus* is a sterile triploid which naturally reproduced vegetatively from rootstocks. Cultivated *Miscantus* can be propagated using either macro- or micropropagation methods. Macropropagation process is time consuming and insufficient to supply the increasing demand for the current commercial development (Rambaud et al., 2013). In micropropagation, the plantlets are regenerated through tissue culture and then established in the field. Increasing requirement for *Miscanthus* × *giganteus* cultivation around the world demand improvement of current micropropagation techniques with the aim to reduce cost of multiplication and increase availability (Kim et al., 2010). The objective of the present investigation was to evaluate the effect of medium composition on direct regeneration of *Miscanthus* × *giganteus*.

Investigation was carried out during 2014–2015 at the JRC Agrobiotechnology Laboratory, Aleksandras Stulginskis University. *Miscanthus* × *gigantheus* Greef et Deuter. rhizomes sterilized and cultivated on Murashige and Skoog (1962) nutrient medium supplemented with different growth regulators concentrations, 10 g L^{-1} sucrose and 8 g L^{-1} Difco-Bacto agar. Explants were cultivated in a growth chamber at 25/20 ºC (day/night), under illumination 50 µmol m^{-2} s^{-1}, photoperiod 16/8 h (day/night). Every four weeks, explants were transferred to the fresh medium. The shoot formation frequency (%) and number of shoots per explant (units) were evaluated. Differences between the treatments for parameters were analyzed using the software STAT (Tarakanovas, Raudonius, 2003). Mean value and standard error (SE) for each treatment were calculated based on the number of independent replication.

Medium composition is one of the most important factors influencing organogenesis from somatic tissues. Combination of 2.4 D and BA was effective to improve plant regeneration in Kim et al. (2010) studies, while Raumbaud et al. (2013) for shoot induction used medium, supplemented with BAP. Our results showed that shoot formation frequency was significantly affected by medium composition. Dependently from growth regulators, concentration in the culture medium shoot formation frequency varied from 10.8 to 18.1%. The significantly highest shoot formation frequency was obtained on the medium supplemented with 0.1 mg L^{-1} TDZ + 3.0 mg L^{-1} NAA. The same medium composition resulted in the highest shoot number per explant. Developed regeneration procedure can be employed in micropropagation and in strategies for further genetic enhancement and improvement of commercial *Miscanthus* × *gigantheus* cultivars.

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THE EFFECT OF POTASSIUM BICARBONATE ON PHOTOSYNTHESIS PARAMETERS OF *SETARIA VIRIDIS* UNDER DROUGHT STRESS

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Drought stress has a serious effect on plant growth and development in many regions of the world. Water deficit is one of the most important environmental factors inhibiting photosynthesis due to an imbalance between light capture and its utilization (Reddy et al., 2004). The ability of plants to acclimate to different stress is directly or indirectly associated with their ability to acclimate at the level of photosynthesis, which affects biochemical and physiological processes and consequently, the growth and development of the whole plant. The aim of this study was to evaluate the effect of potassium bicarbonate on photosynthesis of *Setaria viridis* under drought stress.

The study was carried out at the JRC Agrobiotechnology Laboratory, Aleksandras Stulginskis University. *Setaria viridis* growing in a growth chamber at 25/20ºC (day/night), under illumination 50 μmol m^{-2} s^{-1}, photoperiod 16/8 h (day/night). Drought treatment was started four weeks after germination, when 3 leaves were fully expanded. Potassium bicarbonate was applied by spraying to leaves at concentration 10, 20 and 30 mg l^{-1}. The chlorophyll fluorescence parameters were measured with a fluorometer IMAGING-PAM (Heinz Walz GmbH, Germany). Differences between the treatments for parameters were analyzed using the software STAT (Tarakanovas, Raudonius, 2003). Mean value and standard error (SE) for each treatment were calculated based on the number of independent replication.

The photosynthesis process is impaired by drought stress due to both stomatal and non-stomatal circumscription, which resulted in decreasing of photosynthetic activity (Zlatev, Yordanov, 2004). In the present study, the drought treatment caused a significant decrease in maximum quantum yield, as well as in effective quantum yield of photosystem II in *Setaria viridis*. Statistically significant increase in mentioned parameters under drought stress in comparison with the control was obtained in potassium bicarbonate ($KHCO_3$) treated plants. Under low water content photosynthesis process is inhibited, because the radiant energy absorbed by the plant can transcend the level that photosynthesis is able to dissipate in a usual way. This results in overstock excitation energy with presumptive photoinhibitory effects (Biehler, Fock, 1996). One of the primary mechanisms applied to plants to forbid or reduce damage to the photosynthetic apparatus is non-photochemical chlorophylls fluorescence quenching (NPQ) (Ruban, Horton, 1995). In this way overstock radiant energy is dissipated as heat in the light–harvesting antenna of photosystem II. de Souza et al. (2013) reported that maize genotypes protect their photosystems under drought stress by an increase of non–photochemical chlorophylls fluorescence quenching. The increases in non–photochemical chlorophylls fluorescence quenching under potassium bicarbonate, obtained in our study, indicated protective role of potassium bicarbonate on the photosynthetic system II in *Setaria viridis* under drought stress.

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RESEARCH ON THE GROWING OF PERENNIAL GRASS FOR ENERGY

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Currently a strong interest in renewable energy is a world-wide tendency. Energy plants are herbaceous plants and short rotation energy forests that are grown for their biomass to be used for biofuels, electricity and thermal energy production (Lithuanian Biomass Energy Association LITBIOMA, 2008). Sewage sludge disposal is an urgent issue at the moment. Improperly handled or neglected sewage sludge poses a threat to the environment and human health. One of the ways to dispose it, simultaneously obtaining economic benefits, is composting and using it for fertilization of energy plants (Borkowska, Wardzinska, 2003; Quaye, Volk, 2013).

The trial was performed at the Vokė Branch of the Lithuanian Research Centre for Agriculture and Forestry (LAMMC) in sandy loam *Haplic Luvisols* during 2012–2015. Bioenergy herbaceous plants were planted from seedlings in the spring of 2012. Mugwort (*Artemisia dubia* Wall.) – four individuals per square meter, Virginia fanpetals (*Sida hermaphrodita* (L.) Rusby) and giant miscanthus (*Miscanthus* × *giganteus*) – two individuals per square meter. Fertilization rates: control (no fertilizer), $N_{90}P_{60}K_{90}$ (90 kg ha^{-1} N, 60 kg ha^{-1} P_2O_5, 90 kg ha^{-1} K_2O), 20, 40 and 80 t ha^{-1} sewage sludge compost (SSC) dry matter (DM). Mineral fertilizers were applied every year, and sewage sludge was used once, in 2012, for 3 years.

Tasks: to investigate the influence of fertilization with sewage sludge compost on the growth and biomass formation of perennial grass and to determine the parameters of biomass quality of perennial grass fertilized with sewage sludge compost, regarding the use of biomass for solid biofuel.

On the third year of trial biomass DM yield of giant miscanthus was the highest among the tested herbaceous plants (14.9 t ha^{-1}). The mugwort produced 11.1 t ha^{-1} biomass DM yield, while Virginia fanpetals – 4.0 t ha^{-1}. But the total three-year yield of mugwort was the highest ($p<0.05$).

Fertilization with 20 and 80 t ha^{-1} of SSC significantly increased the mugwort biomass DM yield only on the third year (from 4.9 to 7.0 and 6.8 t ha^{-1} respectively). Fertilization with SSC had no effect on biomass DM yields of Virginia fanpetals and giant miscanthus.

The biomass of giant miscanthus was the most suitable for solid biofuel as it was characterized by significantly lower ash (1.96 – 3.01%), sulfur (0.082 – 0.098%) and total nitrogen (0.24 – 0.41%) contents.

However, calorific value of these plants was only 18.4 – 18.7 MJ kg^{-1}, i.e. significantly lower than of Virginia fanpetals (18.5 – 19.0 MJ kg^{-1}) and mugwort (19.3 – 19.5 MJ kg^{-1}). Mugwort biomass had the highest calorific value, but it contained a lot of S (0.096 – 0.117%) and Nsum. (0.30 – 0.57%). Besides, its ash content was more than 1.5 times higher than that of other herbaceous plants (4.35 –5.21%).

Application of SSC did not significantly change the calorific value of plant biomass. However, application of 20 and 40 t ha^{-1} of compost reduced the ash content in giant miscanthus and Virginia fanpetals biomass, S content in Virginia fanpetals biomass and $N_{sum.}$ concentration in giant miscanthus biomass ($p < 0.05$).

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LIVING MULCH AND WEED COMPETITIVENESS IN MAIZE CROP

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Reduction of weed infestation in agricultural crops has been one of the major concerns recently. Numerous research and observations have been conducted aiming to establish weed spread methods and reasons and weed-crop competition peculiarities. Enhancement of the competitive ability of agricultural crops is one of the principal tools to increase the productivity of agricultural crops.

Research was conducted during 2009–2011 at the Lithuanian University of Agriculture (since 2011 Aleksandras Stulginskis University), Experimental Station. The soil of the experimental field was *Calc(ar)i-Epihypogleyic Luvisol LVg-p-w-cc* (WRB, 2014) with a texture of silty light loam on heavy loam. The soil pH KCl measured 7.1, available phosphorus 134.83 mg kg^{-1}, available potassium 74.66 mg kg^{-1}. The soil in this territory has formed on a bottom moraine or bottom glacial formations, covered by glacial lacustrine sedimentary rock and is a continuation of the Lithuanian Middle Plain. The layer of the sedimentary rock is of different thickness.

A one-factor, stationary field experiment was conducted. Different living mulches inter-seeded in maize inter-rows were tested:

1. Without a living mulch (control – reference treatment);
2. Spring rape (*Brassica napus* L.);
3. White mustard (*Sinapis alba* L.);
4. Spring barley (*Hordeum vulgare* L.);
5. Italian ryegrass (*Lolium multiflorum* Lam.);
6. Black medic (*Medicago lupulina* L.);
7. Persian clover (*Trifolium resupinatum* L.);
8. Red clover (*Trifolium pratense* L.).

In all experimental years, the same living mulches were inter-seeded in the inter-rows of maize monocrop. The plots of the control treatment were weeded out twice. The experiment was replicated four times. The plots were laid out in a randomised design. The total area of an experimental plot was 24 m^2, and the area of a record plot was 20 m^2. In 2009, black fallow preceded maize and in 2010 – 2011 maize was monocropped. Living mulches did not have any significant influence on the stability of soil structural aggregates. The greatest content of moisture was used by the living mulches producing abundant re-growth after each mulching. In many cases, living mulches significantly reduced shear resistance of soil in the middle of summer, when they had covered maize inter-rows. Soil penetration resistance tended to decrease, albeit insignificantly, in the treatments where *Fabaceae* living mulches were grown in maize inter-rows. Living mulches in maize inter-rows increased pH in both layers of the ploughlayer. The growing of living mulches also utilised quite large amounts of P_2O_5 and K_2O, therefore the greatest contents of these elements accumulated in weeded out plots without living mulches. Most of the living mulches tested increased soil C_{org} content; however, no significant differences were established. Higher soil N content was established when growing spring rape (0.22%), white mustard (0.19%), Persian clover (0.21%) and red clover (0.20 %) in maize inter-rows.

Cultivation of living mulches in maize inter-rows exerted a positive effect on soil enzyme activity: urease activity was increased by spring barley, black medic, Persian and red clover living mulches (0.0003–0.0037 mg NH_3 1 g soil per 24 h), while saccharase activity was increased by all living mulches cultivated (4.19–17.66 mg glucose 1 g soil per 48 h). The changes in soil enzyme activity were most markedly influenced by the difference between N_{total} and C_{org} contents in the soil.

Non-regrowing living mulches (white mustard, spring barley and rape) competed with weeds at early development stages when maize competitive ability was poor. Living mulches whose vegetation was longer exhibited better weed suppressive ability and produced more biomass; however, they competed more for nutrients with maize. The correlation regression analysis of the experimental data indicated that at more advanced growth stages of maize, the number and mass of weeds mostly depended on the biomass of living mulches. Living mulches reduced weed seed bank in the ploughlayer by 14.1 to 57.1%. The greatest change was established when growing Persian clover (57.1%) and black medic (53.6%). Most of the *Poaceae and Brassicaceae* living mulches competed more with weeds for space at the beginning of maize vegetation, while *Fabaceae* plants and Italian ryegrass – already after the first mulching of the inter-rows. In most cases, a strong correlation was determined between the surface area covered by weeds and living mulches.

In the first experimental year, while competing with maize, living mulches generally had a significant negative effect on maize biometric and productivity indicators; however, in the final year of the experiment the positive effect of the living mulches was revealed, since with increased nutrient content in the plough layer the competition between the living mulches and maize decreased. In all experimental years, it was established that with increasing total dry mass of the living mulches, the height of maize plants decreased, and the height of maize canopy had the most marked impact on maize productivity.

Cultivation of living mulches in maize inter-rows resulted in an increase in maize grain protein content. The greatest grain protein increase resulted from white mustard (8.84%) and Persian clover (8.57%) living mulches.

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INFORMATION AND SOME RESULTS ON WEED MONITORING IN THE REGIONS OF LATVIA

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The aim of the investigations was to work out science-based recommendations for weed management that are necessary to implement the Integrated Pest Management principles. Research in Latvia has been conducted since 2013, and the field data were collected from the time period from 2011 to 2015. For weed monitoring six stationary arable fields at 50 farms, which differed in size and specialization, were selected in four regions of Latvia. Weeds were monitored by occurrence method (Rasiņš, Tauriņa, 1982) in total in 886 fields from 2013 to 2015.

The aim of this abstract was to inform about the investigations that explain the impact of selected crop, crop sequence, proportion of cereals in crop sequence, soil management system and weed management system on weed species occurrence, the number of weed plants in the crop field, and biological diversity assessed by Menhinick's index.

In arable fields of Latvia, 150 different weed taxa, at species or genus level, were registered during a three-year period. Most common weed taxa were *Viola* spp., *Equisetum arvense* L., *Fallopia convolvulus* (L.) Á.Löve, *Lamium* spp., *Galium aparine* L., *Elytrigia repens* (L.) Nevski, *Veronica* spp. Regional conditions (climate, soils, topography) and years (firstly, weather conditions), as well as interaction of both factors had a significant ($p<0.05$) impact ($\eta^2 A$, %) on the number of weed plants, number of weed species, and Menhinick's index of biological diversity. The differences in above-mentioned weed community were significantly ($p<0.05$) influenced also by increasing proportion of cereals in crop sequence, up to 80–100%.

Selection of main soil management measure: a) tillage; b) shallow tillage before sowing; c) reduced soil tillage with sowing, had a significant ($p<0.05$) impact (η^2 A, %) on the number of weed plants, number of weed species, and Menhinick's index of biological diversity. A significant interaction was detected only with regional conditions, in the authors' opinion, firstly, with differences in soil properties.

An increase in cereal proportion in crop sequence favoured an occurrence of some important volunteer crops, as well as some invasive weed species, including *Avena fatua* L. However, if the number of this weed species among different field crops was compared, the number of *Avena fatua* plants, on average 4 plants m^{-2}, was detected in the fields of spring oilseed rape and that was significantly more than in the areas of winter and spring wheat. These results suggest that *Avena fatua* is an important weed not only in cereal fields, but it is a serious threat and has to be controlled in all arable crops. A specific indicator species, that characterizes the professionalism of field management, is *Elytrigia repens*, – species, which is well studied (much is known about its agrobiological characteristics) and a number of herbicides has been available for its control. An average number of 9 plants m^{-2} and maximum number of 114 plants m^{-2} of *Elytrigia repens* per field indicate a poor level of professionalism. A specific indicator species for acid soils, *Rumex acetosella* L., was detected in 4.7% of total number of investigated fields, but an indicator species for unmanaged soil moisture regime conditions, *Equisetum arvense* L., in 76.4% of investigated crop fields. The research regarding weed monitoring in regions of Latvia will be continued further.

Key words: weeds, weed occurrence, weed management, Integrated Pest Management.

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THE EFFECT OF MULCHES ON *ELYTRIGIA REPENS* SPREADING IN ORGANIC FARMING SYSTEM

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Elytrigia repens is most common weed in Lithuania, and control of this perrenial weed in organic farming system is quite difficult. There is a lack of experimental data on possibilities to use organic mulches for *Elytrigia repens* control. The object of our study was to estimate the influence and the residual effect of different organic mulches on *E. repens* density.

The stationary field experiment was carried out at the Experimental Station of the Aleksandras Stulginskis University. The influence of organic mulches on weed density was evaluated in 2004–2009, the residual effect of the mulches in 2010–2012. Treatments of the experiment: 1) without mulch; 2) straw mulch (chopped wheat straw); 3) peat mulch (medium decomposed fen peat); 4) sawdust mulch (from various tree species); 5) grass mulch (regularly cut from grass-plots).

Grass mulch significantly decreased density of *E. repens* during the whole experiment period. Peat mulch significantly decreased density of *E. repens* except 2006–2007. The influence of straw mulch was unequal: the tendency of higher number of *E. repens* during the first four years of experiment, the tendency of lower number in 2008 and significantly lower number in 2009. The significant influence of all examined organic mulches on *E. repens* density was investigated in 2009, after the six year from the beginning of experiment.

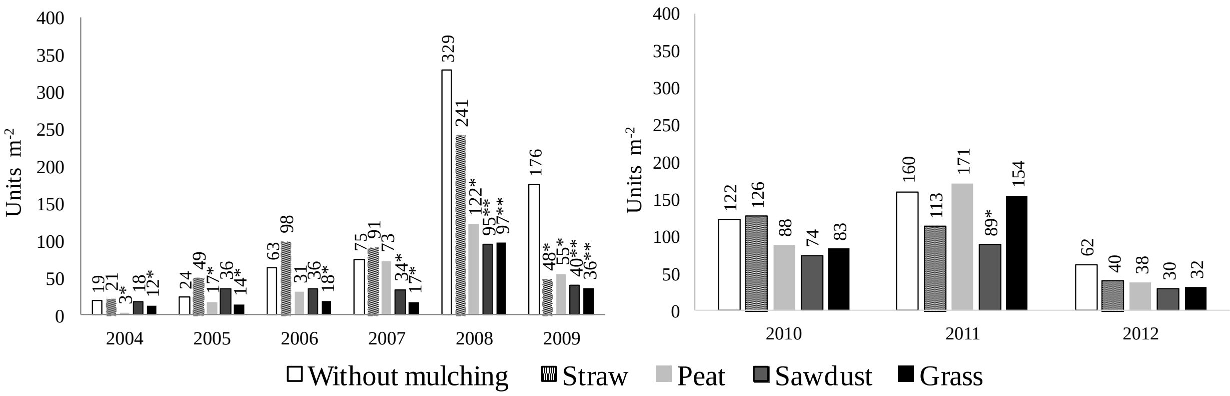

Fig. 1. The influence of organic mulches on *Elytrigia repens* density, 2004–2009. * – 95% probability level, ** – 99%.

Fig. 2. Residual effect of organic mulches on *Elytrigia repens* density, 2010–2012. * – 95% probability level.

The mulches affect the re-growth of *E. repens* at first as a physical barier. After completion of mulching, *E. repens* spreading in experimental plots was unequal. The effect of sawdust mulch on soil agrochemical properties and its allelophatic effect could determine the lower number of *E. repens* in 2010–2012.

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THE ALLELOPATHIC EFFECT OF OILSEED RAPE (*BRASSICA NAPUS*)

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Like other plants of the *Brassicaceae* family, oilseed rape synthesizes allelochemical materials which are released into the air through leaves and roots and penetrate into the soil during the decomposition of rape residues (Velička et al., 2012). The allelochemical compounds affect physiological processes in plants: some plants are stimulated, while others are inhibited (Inderjit et al., 2006; Fuji et al., 2012). The study was carried out at Aleksandras Stulginskis University, and it was aimed to identify the dynamics of accumulation of allelochemicals in oilseed rape as well as the effect of aqueous extracts of different morphological parts of oilseed rape after harvest and different periods of decomposition in the soil on agricultural plants and weeds.

The research revealed the patterns and showed that inhibitory or stimulatory effect of morphological parts of rape residues on agricultural plants and weeds differs and depends on the concentration of residues aqueous extracts and duration of decomposition in the soil. In abstract, part of findings are presented: it was estimated that aqueous extracts of winter and spring oilseed rape different morphological parts residues after harvest at 1:10 concentration significantly ($p \leq 0.05$) inhibited germination of *Hordeum vulgare* (HORVX), *Galium apparine* (GALAP), *Sinapis arvensis* (SINAR) and *Sonhus arvensis* (SONAR) (Fig.). The effect on *Triticum aestivum* (TRAE) and *Tripleurospermum perforatum* (MATIN) germination was lower and in most cases insignificant.

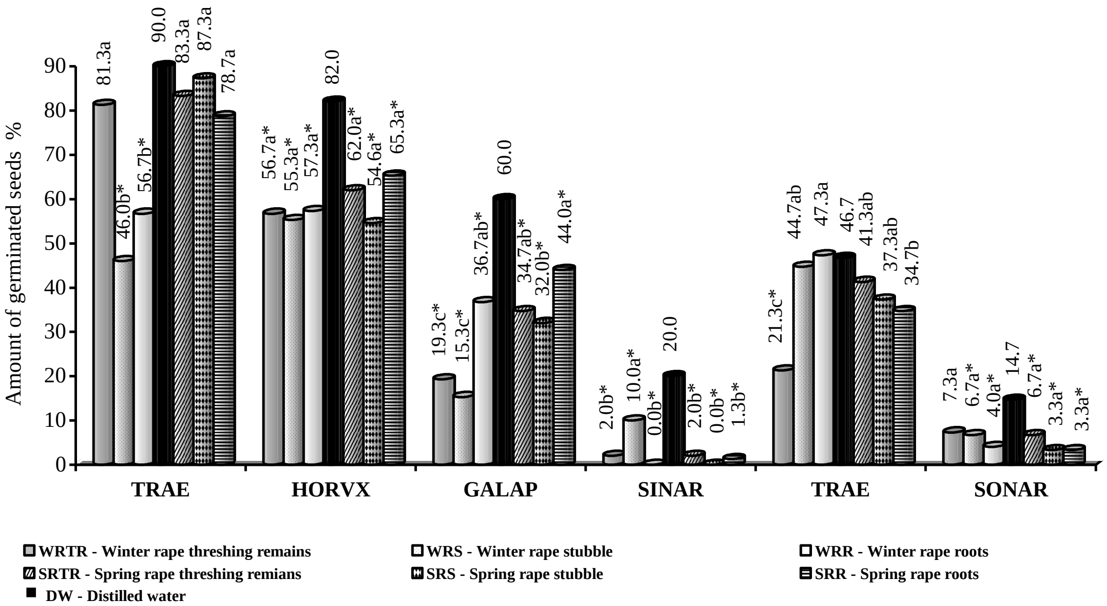

Fig. Amount of germinated seeds of agricultural plants and weeds in the aqueous extract (1:10 concentration) of oilseed rape residues after harvesting

Note: Mean values not sharing the same letter (a, b) and mean values with the asterisk (compared with distilled water) are significantly different ($p \leq 0.05$). Plant codes according to Bayer.

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THE EFFECT OF MANURE AND NITROGEN FERTILIZER ON THE SOIL AGGREGATE STABILITY

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It has been widely known that fertilization affects the soil structure and different kinds of fertilizers have a different effect. A stable structure ensures a better plant growth environment and provides a better absorption of nutrients from the soil. Nowadays the condition of soil is almost exclusively evaluated by chemical parameters and less attention is paid for soil physical parameters.

The study was carried out in Estonia, near Tartu on the long term IOSDV (Internationale Organische Stickstoffdauerdüngungsversuch) experimental field. The soil, based on WRB classification, was an *Albic Stagnic Retisol* (*Loamic*) and had a sandy loam texture. In the current study, the period of 2014 – 2015 was under investigation. The used cultivars: barley ‘Anni’ and potato ’Manitou‘, both were breaded in the Estonian Crop Research Institute. Ammonium nitrate (AN) with different quantities (0, 40, 80, 120, 160 kg ha^{-1} N) was used as a mineral fertilizer and composted farmyard manure (FYM) (40 Mg ha^{-1}) as an organic fertilizer. For undisturbed control, soil from grassland nearby was used. Soil wet aggregate stability (SWAS) from 0 – 2 mm air dried soil samples were analyzed with Eijkelkamp's wet sieving apparatus, by using 0.25 mm sieves.

The results (Fig. 1) revealed the negative effect of AN use as SWAS decreased. In most cases adding FYM increased the SWAS due to the supplementary organic matter. In perspective from the cultivars SWAS variability between the two years was significant. Other researchers have also confirmed that there is a large seasonal variability of aggregate stability (Cosentino et al., 2006). As in 2015 potato shared the same plots as barley in 2014, it can be concluded that there is an individual "field effect" for every field, most likely caused by different texture and saltiness.

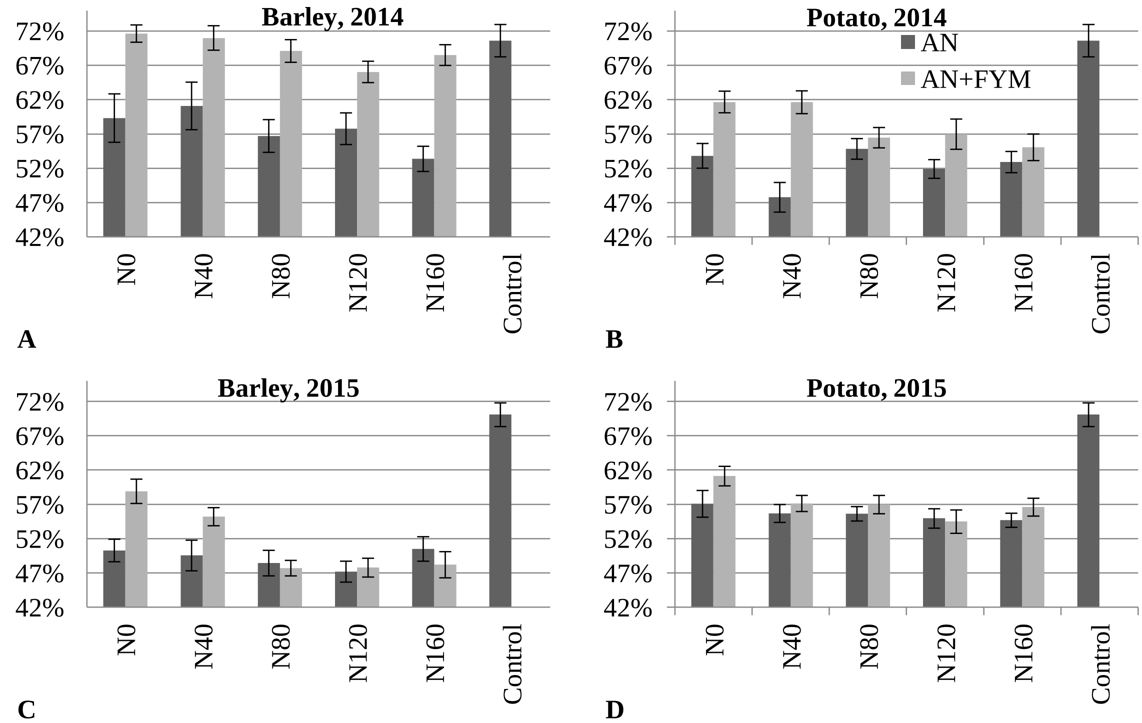

Fig. 1. The percentage value of wet stable aggregate stability on (A) barley and (B) potato in 2014 year and (C) barley and (D) potato in 2015 year. The fertilization, with just ammonium nitrate (AN) and ammonium nitrate with farmyard manure (AN+FYM). The vertical lines show standard error.

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THE INFLUENCE OF WOOD ASH ON THE YIELD OF BARLEY, SPRING WHEAT AND SPRING OILSEED RAPE

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During heat production, wood-fueled boiler houses produce large amounts of wood ash, which today is being mainly disposed in landfills. Wood ash is rich in essential plant nutrients and therefore could be suitable for use instead of mineral fertilizer. The aim of the present study was to compare the effect of wood ash on the yield of barley, spring wheat and spring oilseed rape with mineral fertilizer.

Field experiment was conducted at the Rõhu Experiment station of Estonian University of Life Sciences in 2011 – 2014 on *Stagnic Luvisol* with sandy loam texture, with $P_{Mehlich\ 3}$ and $K_{Mehlich\ 3}$ content 89 and 146 mg kg^{-1} respectively and pH KCl 5.4 at the beginning of the experiment. Treatments (in four replication at randomized block design) were: (i) mineral fertilizer ($N_{80}P_{25}K_{100}$), (ii) wood and peat ash (fuel ratio at combustion 90 and 10%), (iii) control. Application rates of ash were 5, 7.5 and 10 t ha^{-1}. Ash was spread manually and incorporated into the soil at 10 cm of depth in the spring of the first experimental year by using a rotor cultivator. Mineral N fertilizer (80 kg ha^{-1} N) was applied to the ash plots each spring. In mineral fertilizer treatment NPK fertilizer was applied in each year. Crops grown in the experiment were barley, spring oilseed rape, spring wheat and barley in I, II, III and IV year respectively.

Yield was the highest in mineral fertilizer treatment in three years out of four (Table). As an exception in the second year the yield was the highest in treatment with ash applied at the rate of 7.5 t ha^{-1}. In the last two years, the grain yield in mineral fertilizer treatment was already 0.7–1.1 t ha^{-1} higher if compared to treatments with ash. Wood ash is efficient at acidic soils (Arshad et al., 2012) and soils with low nutrient content (Füzesi et al., 2015). Present research showed that despite acidic soil the application of ash resulted in similar yield as with mineral fertilizer only in the first two years. Although there was no significant correlation between the ash application amount and crop yield, the yields were still higher in treatments with ash application rates of 7.5 and 10.0 t ha^{-1}.

Table

Crop yields (t ha^{-1}) in different treatments

Treatment	Experimental year/crop				Average yield
	I	II	III	VI	
	Barley, 'Teele'	Spring oilseed rape, 'Larissa'	Spring wheat, 'Specific'	Barley, 'Anni'	
Control	2.2^{a}	2.3^{a}	4.2^{a}	2.8^{a}	2.9^{a}
Mineral fertilizer	3.0^{c}	3.2^{ab}	6.4^{b}	6.0^{b}	4.7^{b}
N_{80} + ash 5.0 t ha^{-1}	2.3^{ab}	2.9^{ab}	5.3^{ab}	5.3^{ab}	4.0^{ab}
N_{80} + ash 7.5 t ha^{-1}	2.4^{ab}	3.4^{b}	5.4^{b}	5.3^{ab}	4.1^{ab}
N_{80} + ash 10.0 t ha^{-1}	2.8^{bc}	2.9^{ab}	5.3^{ab}	5.3^{ab}	4.1^{ab}

The effect of wood ash on crop yield is similar or slightly lower than with mineral fertilizer.

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DIRECT AND RESIDUAL EFFECT OF ORGANIC WASTE COMPOST ON THE CROP PRODUCTIVITY

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Sustainable use of fertilizers is important for maintaining balanced nutrient cycling in agro-ecosystem, soil quality and crop productivity. Considering the high costs and energy demand of mineral fertilizers, it is increasingly important to use more alternative nutrient sources such as composts. Compost use is likely to enhance soil quality and crop yields as indicated in several studies (Arthur et al., 2010; D'Hose et al., 2012). Nutrient release from organic fertilizers is slower compared to mineral fertilizers and thus their effects need to be evaluated over longer time periods. Effect of fertilizer use on the crop yield is widely studied, but relatively less information has been presented on the residual effects of fertilizers, especially in Nordic climatic conditions (Riley, 2016). Residual effect of organic fertilizers is in most cases studied with animal manures (Mallory et al., 2010; Petersen et al., 2010; Cela et al., 2011; Riley, 2016), but even more scarce are studies with non-manure based composts. The largest waste composting facility in Estonia is Tallinn Waste Recycling Centre (max 15 000 t year^{-1}). Although compost is produced, the utilization of it is unsolved. The reputation of waste compost has been low, as there is no long historic experience using waste composts in Estonia. The aim of current study was to evaluate first year direct effect and residual effect of waste compost on the crop productivity.

Crop rotation field experiment to reveal direct effect of compost to the spring barley yield and residual effect to potato and spring wheat yield was conducted in Tartu, Estonia on pseodopodzolic soil with low humus concentration (< 2%). Compost was produced from source separated food and green waste, and category III animal by-products; and composted in aerated covered static piles for six weeks and after that matured in open windows for minimum six months. Compost originates from Tallinn Waste Recycling Centre. Compost was applied to soil with ploughing in autumn before spring barley growing season (in years 2012 – 2014). Compost was applied in three norms according to total N (200, 275 and 350 kg ha^{-1}) (Table), variants are further referred respectively C200, C275, C350. In addition, there was unfertilized control plot and all experimental variants were three times replicated. The plot size was 50 m^2. First year residual effect to the potato tuber yield was estimated in years 2013 – 2015. Second year residual effect to yield of spring wheat was studied in 2014. Absolute values of different crop yields cannot be directly compared; therefore, we calculated relative yield indexes as a ratio to the control plots and expressed proportional yield increase (%). Effect of compost on the crop yield was first tested by ANOVA and in the case where this factor was significant ($p<0.05$) post-hoc Dunnet test was performed (control plot versus compost norms).

Table

Chemical composition and application rates of compost

Year	Dry matter %	pH KCl	N_{tot} %	P_{tot} %	K_{tot} %	Rates t ha^{-1}
2012	64	7.0	3.27	1.04	0.97	10/13/17
2013	38	7.4	3.34	3.08	0.87	16/22/28
2014	64	7.1	4.0	0.53	0.90	8/11/14

Direct effect of compost application on the increase of barley yield was statistically significant ($p < 0.001$). The highest increase of barley grain yield with the use of compost was in 2014. As an average of three years (2012 – 2014) barley yield increased by 0.87, 1.13 and 1.52 t ha^{-1} with compost norm 200, 275 and 350 kg N ha^{-1} respectively. There were no significant differences in grain yields between compost application norms. Three year average proportional yield increase in first growing season after compost application was in range 40 – 50% (Figure).

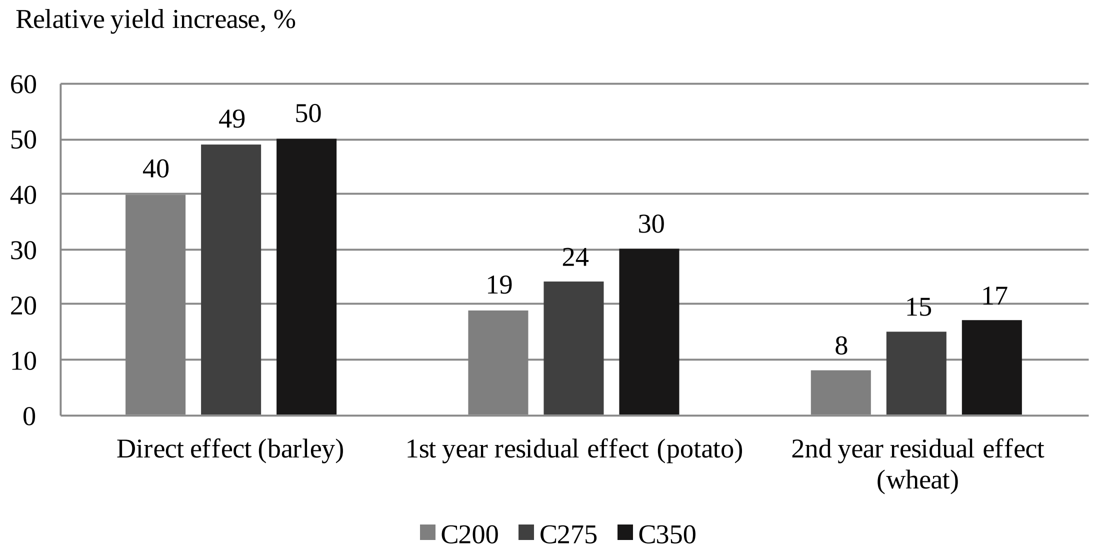

Figure. Yield increase (%) with the use of compost compared to the unfertilized control plot. C200, C275 and C350 - compost

First year residual effect to the potato yield was significant ($F = 8.9$; $p < 0.001$). All compost norms resulted in significant yield increase compared to the unfertilized control plot. In this case, the lowest compost rate (200 kg N ha^{-1}) yield increase was 19% (Figure 1). The second year residual effect of compost use to spring wheat grain yield was already smaller (8 – 17%) and statistically non-significant ($F = 3.2$; $p = 0.07$). Residual effect of compost is decreasing year-by-year as expected. In the third growing season after application the effect is not significant, but it is still important to consider, especially if we take in account cumulative yield increase through all crop rotation.

First year effect of compost increased barley yield by 40 – 50%, first year residual effect resulted in increase of potato yield by 19 – 30% and second year residual effect to wheat yield was in the range from 8 to 17%. In addition to the first year yield increase, it is very important to consider positive residual effect of compost use.

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LONG-TERM IMPACT OF REDUCED INTENSITY TILLAGE SYSTEMS, STRAW AND GREEN MANURE COMBINATIONS ON SOIL AGGREGATION, WATER CAPACITY, PORE STRUCTURE AND BULK DENSITY

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Since 1999, a long-term field experiment has been done at the Experimental Station of Aleksandras Stulginskis University at 54º52′50 N latitude and 23º49′41 E longitude. The soil of the experiment site is *Epieutric Endocalcaric Endogleyic Planosol* (*Endoclayic, Aric, Drainic, Humic, Episiltic*) according to WRB (2014), texture at 0 – 20 cm depth is silty medium loam (33.7% sand, 50.3% silt, 16.0% clay), at 20 – 40 cm depth – silty light loam (35.4% sand, 51.1% silt, 13.5% clay). The objective of our investigations was to assess the long-term impact of reduced intensity tillage systems, straw and green manure combinations on soil aggregation, water capacity, pore structure and bulk density.

A short crop rotation was introduced: winter wheat, spring barley, spring rape. The results were obtained in 2014 when winter wheat was grown. According to two factor field experiment, the straw (factor A) was removed (R) from one part of the experimental field and on the other part of the field all straw yield was chopped and spread (S) at harvesting. As a subplot 6 different tillage systems (factor B) were investigated: conventional ploughing (CP) at 23 – 25 cm depth in autumn, shallow ploughing (SP) at 10 – 12 cm depth in autumn, shallow loosening (SL) with sweep cultivator and disc harrow at 8–10 cm depth in autumn, shallow rotovating (SR) at 5 – 6 cm depth before next crop sowing, catch cropping for green manure and rotovating (GMR) at 5 – 6 cm depth before next crop sowing, no-tillage (NT), direct drilling. Catch crop white mustard (*Sinapis alba* L.) for green manure was undersown on stubble only in GMR plots just after winter wheat and spring barley harvest. The trials were replicated four times. The treatments were arranged using a split-plot design. The total size of each plot was 102 (6 × 17) m^2 and net size was 30.0 (2.0 × 15) m^2. The soil samples have been analysed in the Agro-biological laboratory of Aleksandras Stulginskis University.

The results after 15 years of investigation showed that continuous straw retention decreases amount of micro aggregates (< 0.25 mm) and increases aggregate stability in 10 – 25 cm depth to compare with 0 – 10 cm depth. In plots without straw there was no significant differences. Soil tillage has no significant effect either. Compared with conventional deep ploughing, no-tillage in the deeper layer increases volumetric water content at water column 4 – 30 cm height, which means that it can hold more water at low pressure. Other tillage treatments and straw incorporation have no effect. Straw retention has no influence on soil pore structure. Compared with conventional deep ploughing, shallow loosening decreases total porosity, especially of macro pores in both upper and lower soil layers. No-tillage had no positive effect on total porosity in the upper soil layer, and in deeper soil layer it even increased, especially the amount of macro pores. Straw retention has no influence on soil bulk density. Compared with conventional deep ploughing, shallow loosening increases soil bulk density both in upper and lower soil layers. No-tillage does not influence bulk density in upper soil layer, but in deeper soil layer this indicator of soil compaction even decreases.

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SOIL STRUCTURE AND ORGANIC MATTER ASSESSMENT IN CROP ROTATION

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The number of scientific studies has shown that plant-soil interactions are a driving force for primary productivity, nutrient and carbon cycling, vegetation dynamics, and ecosystem responses to global change. However, soil management itself can influence the changes in soil stability and productivity. The decrease of soil organic matter content is mainly related with low organic matter inputs. Thus, accumulated humus is then intensively mineralized or dehumified. The farm practices survey in Lithuania has indicated that short crop rotation of three-course (45%) and 4-year crop rotation (36%) with more nutrient exhausting crops are the most dominant. It was also indicated that in the research knowledge implementation young farmers (20-30-year-old, 45% of the questioned farmers) have been more active, but middle age farmers (41-50-year-old, 22% of the questioned farmers) have been less active to apply knowledge.

Our research revealed that there has been the tendency that along the increase in organic matter content soil structure and stability of aggregates have been increasing. The regression analysis showed the linear reliance of water-stable soil aggregates on the content of organic carbon ($r = 0.70$), and the soil bulk density ($r = 0.59$), as well as on the soil aeration porosity ($r = 0.32$). Thus, the quantity of the stable aggregates has had a large positive effect not only on the content of organic carbon but also improved soil aeration porosity and soil bulk density. Although plant by-residues did not change soil organic carbon content essentially (Fig.), however in general, it has been a supporting factor to maintain humification and mineralization processes in balance.

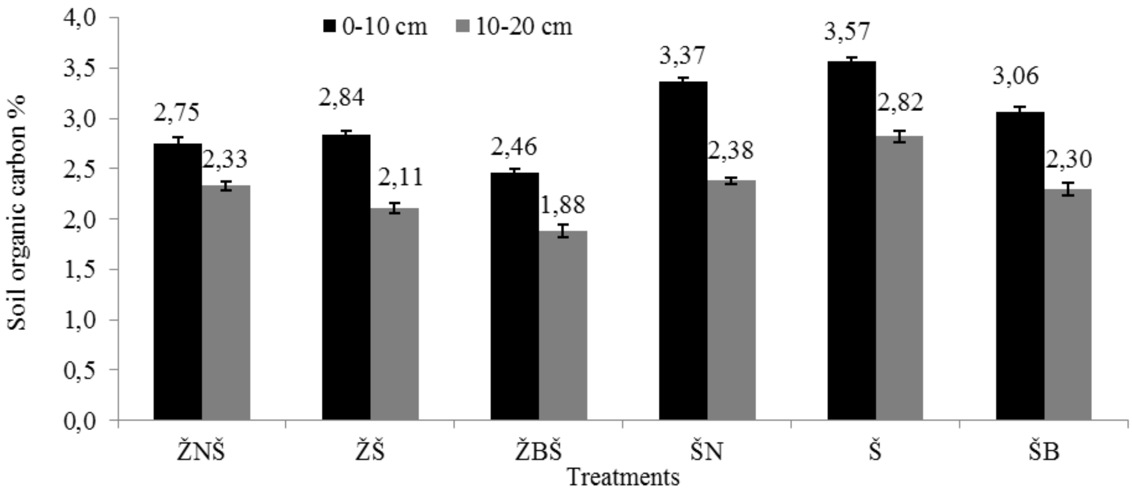

Fig. Soil organic carbon content in plough layer at different depth under the barley crop. Klovainiai (Lithuania), 2014 (ŽNŠ– white mustard for green manure, nitrogen and removed straw, ŽŠ – white mustard for green manure and removed straw, ŽBŠ – white mustard for green manure, biological preparation and removed straw, ŠN – removed straw and nitrogen, Š – removed straw ŠB – removed straw and biological preparation).

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THE EFFECT OF ALTERNATIVE CROPPING SYSTEMS ON THE DYNAMICS OF THE MAIN NUTRITIONAL ELEMENTS IN THE SOIL

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Experiments were conducted at Joniškėlis Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry in 2006–2013, in the soil which is characterised by low phosphorus and high potassium contents. The research was carried out in the crop rotation's grass-cereal sequence: perennial grasses (grown as green manure) → winter wheat. The literature suggests that the use of farmyard manure at the optimum incorporated amount of 40 Mg ha^{-1} can compensate for losses resulting from being removed from the soil through harvesting (Bergström et al., 2015). The aim of experiments is to determine the changes of biogenic soil elements in the organic cropping systems by using farmyard manure and aftermath of red clover for green manure or their combinations for winter wheat fertilization, and in sustainable cropping systems – by replenishing the amount of nutritional elements with mineral fertilizers. The NP balance was strongly positive and K was significantly in excess in the organic cropping system when the green manure had been used in combination with 40 Mg ha^{-1} of farmyard manure (Table).

Table

Changes of P_2O_5 and K_2O amount in soil, mg kg^{-1}

Cropping system	Organic and mineral fertilizers	P_2O_5	K_2O
Beginning of rotation			
Organic I	aftermath of perennial grass	122.30	219.90
Organic II	aftermath of perennial grass + farmyard manure 40 Mg ha^{-1}	105.55*	206.11*
Sustainable I	farmyard manure 40 Mg ha^{-1}	96.11*	206.40*
Sustainable II	aftermath of perennial grass + $N_{30}P_{60}K_{60}$	120.94	229.13*
End of the first crop rotation, 2006–2009			
Organic I	aftermath of perennial grass	100.50	204.73
Organic II	aftermath of perennial grass + farmyard manure 40 Mg ha^{-1}	103.50	219.42*
Sustainable I	farmyard manure 40 Mg ha^{-1}	103.10	217.52*
Sustainable II	aftermath of perennial grass + $N_{30}P_{60}K_{60}$	124.52*	212.84*
End of the second crop rotation, 2010–2013			
Organic I	aftermath of perennial grass	86.96	204.00
Organic II	aftermath of perennial grass + farmyard manure 40 Mg ha^{-1}	95.46*	224.25*
Sustainable I	farmyard manure 40 Mg ha^{-1}	97.00*	246.00**
Sustainable II	aftermath of perennial grass + $N_{30}P_{60}K_{60}$	107.25**	218.05

A marked reduction in the available phosphorus content in the soil was established when green manure or 40 Mg ha^{-1} of farmyard manure or their combinations had been applied. Also, potassium levels increased in the organic cropping system where green or farmyard manure had been applied. When 40 Mg ha^{-1} of farmyard manure and N_{30} mineral fertilizer had been used in the sustainable cropping system to promote straw mineralization, in the sustainable cropping systems that had used the perennial grass aftermath as green manure with minimum rates of mineral fertilizer $N_{30}P_{60}K_{60}$, N balance was negative, P – marginally positive, K value was positive, marginally negative. In the sustainable cropping system, where perennial grass aftermath for green manure and $N_{30}P_{60}K_{60}$ had been used for winter wheat during two 4-field crop rotations the available phosphorus and potassium quantity in the soil showed a trend towards decreasing.

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INFLUENCE OF PREPARATION ALBIT ON MEMBRANE INJURY OF WINTER WHEAT DURING COLD STRESS

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Low temperature is one of the primary stress factors that limits growth and productivity of winter annual plants. Winter plants have evolved survival mechanisms that are temperature regulated to cope with low temperature stress. During cold acclimation, several physiological, biochemical and molecular changes occur. Accumulation of soluble carbohydrates is one of the best-known responses of plants to cold. It begins early during the response to cold. Sugars may depress the freezing point of the tissue, and act as a nutrient and energy reserve, alter phase properties of membranes in the dry state, and act as cryoprotectants to preserve protein structure and function (Xin, Browse, 2000). Frost tolerance field studies are difficult to replicate due to the extreme environmental variability. Because of this variability, the laboratory procedures to measure freezing tolerance have been developed by a number of investigators. In several crops, assessing membrane stability by measuring electrolyte leakage following a simulated freeze-thaw stress is a rapid and reliable screening technique for freezing tolerance (Rife, Zeinali, 2003). The objective of this study was to evaluate the effect of preparation *Albit* on membrane injury of winter wheat shoots cultured *in vitro*.

The study was carried out at the JRC Agrobiotechnology Laboratory, Aleksandras Stulginskis University with winter wheat cultivar 'Aura'. Shoots were cultivated on Murashige and Skoog medium, supplemented with 2.0 g L^{-1}, 4.0 g L^{-1} and 6.0 g L^{-1} concentrations of preparation *Albit*. Shoots were acclimated in a vernalization chamber at 4ºC temperature for 14 days. Total soluble sugars (reducing and nonreducing) were determined according Yemm, Willis (1954). The membrane injury for leaf discs was estimated by the electrolyte leakage test according to Rapacz (2002). Differences between the treatments for parameters were analyzed using the software STAT (Tarakanovas, Raudonius, 2003). Mean value and standard error (SE) for each treatment were calculated based on the number of independent replication.

During the plant cold acclimation, the content of most solutes in leaf cells increases, and there is evidence from several studies that at least some of these solutes may be important for the development of freezing tolerance. We have therefore measured the amounts of soluble sugars in leaf samples from all treatments before and during cold acclimation. Sugars may depress the freezing point of the tissue, and act as a nutrient and energy reserve, alter phase properties of membranes in the dry state, and act as cryoprotectants to preserve protein structure and function. Sugar accumulation at cold temperatures has been widely documented in different plants. The results of the present study demonstrate that after days of cold acclimatization soluble sugars content in winter wheat shoots increased only 1.5 times in comparison with non-acclimated shoots. On the medium supplemented with preparation *Albit* electrolyte leakage of treated shoots was approximately 18% lower in comparison with non-treated shoots. Our results are in agreement with other researchers studies. Sasaki et al. (1996) reported that sugar contents were not always consistent with the degree of freezing tolerance and that factors other than sugar may also affect freezing tolerance.

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THE EFFECT OF SULPHUR FERTILISATION ON THE YIELD OF SPRING WHEAT

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Sulphur is one of four main organogenic elements that are essential for plants (Mašauskas at al., 2005). Positive results of the application of this element to cereals have been reported by many researchers (Zhao et al., 2006). However, the presented data regarding the effect of sulphur on wheat differ: some researchers state that sulphur fertilisation has significant influence on the yield (Weiser et al., 2004), others maintain that sulphur improves the quality of grains (Flaete et al., 2005), and still others claim that sulphur fertilisation increases the yield and improves the quality of grains (Staugaitienė et al., 2013). Lithuanian research into total qualities of sulphur in the leaves of spring wheat at 28 and 55 BBCH stages showed that the quantity of this element was close to the lower optimum threshold. The optimum recommended quantity at these stages is > 0.3% (Breuer et al., 2003).

In 2013–2014, research was conducted at Rumokai Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry to determine the effect of sulphur fertilisation on the yield of spring wheat. Before the sowing of spring wheat, soil samples were taken. In accordance with agrochemical indicators of the soil and the software "Racionalus tręšimas" ("Efficient Fertilisation"), the rate of NPK fertilisers was calculated. Spring wheat was treated with ammonium nitrate, potassium chloride, and diammonium phosphate. Additionally, the following experimental ammonium sulphate fertilisation scheme was applied: 1) Control; 2) Ammonium $sulfate_{15}$ before sowing; 3) Ammonium $sulfate_{3,6}$ at 32–33 BBCH stage via leaves.

During research years, it was ascertained that if spring wheat is treated with sulphur before sowing, the grain yield increases by 2.1% on average, while leaves treatment at 32-33 BBCH stage leads to an increase of 4.9% compared with areas untreated with sulphur. The increase of yield following leaves treatment was statistically reliable during both years of research. Sulphur treatment during the main fertilisation resulted in a significant increase of the number of productive stems. In addition, sulphur fertilisation before sowing increased the number of grains per ear by 3.7%. With regard to the 1000 grain weight, a more significant impact was caused by additional treatment of wheat leaves with sulphur fertiliser. No relation was discovered between sulphur fertilisation and crude protein content in the grains of spring wheat.

Table

The effect of sulphur fertilisation on the grain yield of spring wheat, its structural indicators and quality

Fertilisation	Grain yield		Number of productive stems		Number of grains per ear		1000 grain weight		Crude protein	
	t ha^{-1}	rel.	units m^{-2}	rel.	units	rel.	g	rel.	%	rel.
NPK (control)	5.36	100.0	615	100.0	32.1	100.0	36.89	100.0	11.60	100.0
$NPK+S_{15}$	5.47	102.1	639	103.9	33.3	103.7	37.05	100.4	11.36	97.9
$NPK+S_{3.6}$	5.62	104.9	615	100.0	32.1	100.0	37.94	102.8	11.44	98.6
R_{05}	0.151	×	18.665	×	2.23	×	0.492	×	0.475	×

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IMPACT OF CLIMATE VARIABILITY ON PRECIPITATION FILTRATION IN LITHUANIA

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Percolating moisture regime is typical in many Western and Eastern European countries, and percolated precipitation significantly influences chemical composition of groundwater and river runoff. Agricultural lands, where various agro-technical measures are used for crop yield enlargement, very negatively affect the quality of underground water basins and reservoirs (Adomaitis, 2010, Sørensen et. al., 2012).

Meteorological data of the last decades show warming of the climate: the average annual air temperature has increased by 0.1–0.9 °C, the highest increase is observed in late autumn and spring temperatures; the number of days with negative temperatures has decreased (Kriauciuniene et. al., 2012). Changes in the air temperature and precipitation amount, and intensity can affect rainfall infiltration.

The aim of this work is to assess the impact of varying climate conditions on the filtration of atmospheric precipitation in sandy loam soil based on the data on precipitation filtration obtained in the course of experiments in stationary lysimeters during the years 1987–2014. Linear function ($y = a + bx$) of infiltration of precipitation for a certain season of year (spring, summer, autumn, winter) has been applied to definition of trends of infiltration change during 1987–2014.

Over the study period, during the hydrological year 36.4-50.9 % of precipitation (254.1–347.9 L m^{-2}) was infiltrated in sandy loam soil. Since 2002 the amount of infiltration water has been gradually increasing, and it was influenced not just by larger precipitation amount but also by other factors. Annual rainfall amount weakly correlated with the extent of infiltration ($r = 0.32$). This shows that in Lithuania infiltration is strongly influenced by thermal regime, evaporation conditions, as well as rainfall intensity, as noted by other researchers as well (Mclsaac, 2012). More abundant infiltration takes place during the spring – on average 33.9% of the annual amount of infiltrate. Until the spring of 2002, the average amount of infiltrate was 89.3–86.0 L m^{-2} $year^{-1}$, and since 2003 the amount reached 131.1–115.2 L m^{-2} $year^{-1}$. During the summer season rainfall infiltration was small, and during 1987–2014 it accounted for an average of 13.8 % (42.8 L m^{-2}) of annual infiltrate content. Since 2002, due to increased rainfall, infiltration in summer intensified, and in 2009–2014 it accounted for 15.7% (52.2 L m^{-2}) of annual infiltrate content. During the summer the amount of infiltrate strongly correlates with rainfall amount ($r = 0.84$). In 1987–2014 autumn infiltrate comprised 25.8 % (80.1 L m^{-2}) of annual infiltrate amount. Until 2009 infiltration volumes were fairly similar – 65.0–76.3 L m^{-2}, but during 2009–2014 they increased up to 108.3 L m^{-2}, which resulted in more intense infiltration in September. In winter period during 1987–1992, the average amount of infiltrate was 105.7 L m^{-2}, while up to 2009–2014 it consistently declined to 57.3 L m^{-2}. Infiltration mostly declined during January and February.

During 1987–2014 on the territory of Lithuania, due to increasing temperature and longer spring and autumn periods, the annual amount of precipitation infiltrate slightly increased ($y_{annual} = 17.0x + 267.9$; $R^2 = 0.29$). The trend towards increased infiltration was recorded for spring ($y_{spring} = 12.3x + 74.7$; $R^2 = 0.54$), summer ($y_{summer} = 4.8x + 30.8$; $R^2 = 0.45$) and autumn ($y_{autumn} = 12.4x + 49.2$; $R^2 = 0.680$), while in winter the infiltration amount reduced ($y_{winter} = -12.4x + 113.3$; $R^2 = 0.56$).

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EFFECT OF L-GLUTAMIC ACID ON COLD TOLERANCE OF WINTER RAPESEED SHOOTS

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Cold and frost limit the growing seasons and geographic distributions of plants, but most overwintering plants are able to increase their freezing tolerance when exposed to non-freezing low temperatures, a process known as cold acclimation. Survival of plants at freezing temperatures is dependent on their ability to cold acclimate in response to environmental stimuli such as short-days and low temperatures (Xin, Browse, 2000). During the plant cold acclimation, the content of most solutes in leaf cells increases, and there is evidence from several studies that at least some of these solutes may be important for the development of freezing tolerance (Trischuk et al., 2006). Many investigators have ascribed to proline a positive role associated with some sort of adaptive response. The core of proline metabolism involves two enzymes catalyzing proline synthesis from glutamate in the cytoplasm or chloroplast, two enzymes catalyzing proline catabolism back to glutamate in the mitochondria (Verslues, Sharma, 2010). The aim of the present experiment was to evaluate the influence of L-glutamic acid on cold tolerance of winter rapeseed shoots.

Investigation was carried out during 2014-2015 at the JRC Agrobiotechnology Laboratory, Aleksandras Stulginskis University with winter rapeseed cultivar ‘Cult’. Shoots were cultivated on Murashige Skoog medium, supplemented with 10.0 mM, 15.0 mM and 20.0 mM concentrations of L-glutamic acid. Shoots were acclimated in a vernalization chamber at 4ºC temperature for 14 days. Endogenous proline content was determined using a revised ninhydrin method (McClinchey, Kott, 2008). The membrane injury for leaf discs was estimated by the electrolyte leakage test according to Rapacz (2002). Differences between the treatments for parameters were analyzed using the software STAT (Tarakanovas, Raudonius, 2003). Mean value and standard error (SE) for each treatment were calculated based on the number of independent replication.

Our results showed that application of tested concentration of L-glutamic acid significantly increased the amount of endogenous proline in winter rapeseed under low positive temperature. L-glutamic acid treated shoots showed significantly higher endogenous proline content compared with control shoots. The highest level of endogenous proline has been observed in shoots cultured on medium supplemented with 20.0 mM L-glutamic acid. Cold tolerance (expressed in terms of electrolyte leakage) of winter rapeseed shoots cultured with and without L-glutamic acid has been evaluated. The highest electrolyte leakage has been obtained from leaves of acclimated shoots without L-glutamic acid treatment. Several comprehensive studies using transgenic plants or mutants demonstrate that proline metabolism has a complex effect on development and stress responses, and that proline accumulation is important for the tolerance of certain adverse environmental conditions (Verslues, Sharma, 2010). In present study, the addition of L-glutamic acid to culture medium resulted in significant increase of endogenous proline in rapeseed shoots and subsequently in significant increase in cold tolerance. On the medium supplemented with L-glutamic acid electrolyte leakage of treated shoots was approximately 20% lower in comparison with non-treated shoots.

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ARBUSCULAR MYCORRHIZAL COMMUNITY COMPOSITION OF NEW EUROPEAN POTATO VARIETIES GROWN IN CONVENTIONALLY TREATED FIELD SOIL

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The growth of agricultural yields in recent years relies mainly on the use of synthetic fertilizers and pesticides and therefore has a strong negative impact on the environment. To ensure the sustainable development of agriculture, alternative solutions should be considered. One of such options could be the use of arbuscular mycorrhizal fungi (AMF). AMF are ecologically and agriculturally important symbionts because they improve plant mineral nutrition, notably with phosphorus (P) and other non-labile mineral nutrients essential for plant growth in many crops (Smith and Read, 2008). Therefore, AMF potentially plays important roles in sustainable plant production systems that reduce or eliminate synthetic chemical inputs (Douds et al., 2007). AMF assemblages in the soil are affected by different management systems, fertilization regimes and usage of chemical fungicides (Jansa et al., 2002; Kabir, 2005; Jansa et al., 2009; Buysens et al., 2015). Moreover, these fungi are also dependent on host genotype (Song et al., 2015). Although AMF is holding a wide host range, some AMF-plant host combinations are more preferred than others. The aim of the study was to get new knowledge about AMF-plant genotype incompatibility. Therefore, in total 315 soil and root samples were collected in 2013 from plants of 21 different potato varieties. The field site of the sampling was located in Reola, Estonia (58°17'02.0"N 26°43'19.6"E). AMF community composition was assessed by using Illumina Mi/Seq sequencing of ITS2 region.

Results showed that the community structure of AMF was different across all varieties of potato. Furthermore, the composition varied between growth stages in both rhizosphere soil and plant roots. The AMF community composition of soil was the lowest before plant emergence. In contrast, in the senescence stage of plants more diverse structure was observed. The same pattern was noticed in the root samples. Also, root samples at different growth stages exhibited a different distribution of AMF. AMF found present in emergence phase, were absent in senescence phase and vice versa.

Our study demonstrates a complex interaction between a plant host and their associated AMF. Plant genotype exhibits an important role creating AMF community in roots. Additionally, our results suggest that the aspects of AMF communities may be partially explained by the plant productive stage which also has a broader effect on the plant rhizosphere structure as a whole.

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COMPARISON OF THE EXTENT OF COLONIZATION OF ARBUSCULAR MYCORRHIZA IN PLANT ROOTS IN DIFFERENT CULTIVATION PRACTICES

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The increasing demand for food leads to higher usage of chemical fertilizers and synthetic biocides. Therefore, there is an urgent need to find novel approaches to enhance sustainable agriculture while not reducing crop yields. Arbuscular mycorrhizal fungi (AMF) may provide an alternative to reduce the high inputs of fertilizers and pesticides (Augé, 2015; Smith & Smith, 2011). Potato (*Solanum tuberosum* L.), one of the largest food crops in the world has the heaviest demands for fertilizers and pesticides of all vegetable crops (Wu et al., 2013) and these have a negative impact on AMF (Verbruggen et al., 2010).

This study investigated the extent of colonization of potato roots by indigenous AMF in the field soil under different agricultural treatments, including different fertilization regimes. Our field trials comprised the extent of AMF colonization of potato roots in conventionally and organically managed fields. Root samples were collected in 2010 from plants of the potato variety “Reet”. The field site for the root sampling was located in Tartu, Estonia (58°22´ N, 26°40´ E). Root samples were stained according to Koske & Gemma (1989), and root colonization was estimated by McGonigle et al., 1990.

The results show that the extent of AMF colonization in potato roots was extremely low in both farming systems. To evaluate the inoculum potential (IP) in the field soil, *Plantago lanceolata* L was used. The data from pot experiment showed the positive effect to growing amounts of mineral fertilizers due to improved plant growth and then confirmed the negative impact of too high amount of mineral fertilizers. Moreover, the low-input system showed a greater extent of colonization in roots compared to the roots originating from the sites with the high-input system. Our findings confirm that the natural AM fungal community was able to infect plants. Thus, plant species was a significant factor affecting AMF colonization, and the IP of field soil depends on agricultural treatments.

Therefore, we conclude that understanding the impact of agricultural treatments on AMF colonization would help to design agricultural practices that maintain healthy AMF functioning thus aiming to reduce agricultural chemical inputs.

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NITROGEN EFFECT ON WINTER WHEAT GRAIN PROTEIN CONTENT

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Winter wheat (*Triticum aestivum* L.) is one of the most productive and significant cereal species in Latvia used for food grain production. Protein content is a primary quality component that mostly influences the baking quality characteristics of wheat grain (Koga et al., 2015). Protein accumulation in bread wheat largely depends on the distribution of nitrogen rates during the growing season (Chope et al., 2015). The aim of this investigation was to clarify variation of protein content on winter wheat grain depending on different nitrogen fertilizer rates.

Field experiments with winter wheat cultivars 'Bussard' and 'Zentos' were conducted at the Latvia University of Agriculture, Study and Research farm "Peterlauki" (latitude: 56° 30.658′, longitude: 23° 41.580′) during a three year period (from 2009/2010 to 2011/2012), *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. Phosphorus and potassium fertilizers were applied in autumn P_2O_5 – 72 kg ha^{-1} and K_2O – 90 kg ha^{-1}. Nitrogen (N) was applied (N60, N90, N120, N150 kg ha^{-1}) in spring after resumption of vegetative growth. Grain protein content (PC) was calculated multiplying total nitrogen content (determined by Kjeldahl method (ICC 105/2)) by factor 5.7. Experimental data processing was done using two–factor analysis of variance (ANOVA), the least significant difference ($LSD_{0.05}$) also was determined.

Average data in our investigation (3 years) suggest that protein content in cultivar 'Bussard' grain was from 139.2 to 147.5 g kg^{-1}, it was significantly ($p < 0.05$) higher, compared to 'Zentos' – 113.2 to 131.2 g kg^{-1} (Table).

Table

Protein content (g kg^{-1}) in winter wheat grain depending on nitrogen fertilizer rate

Nitrogen fertilizer (N) rate, kg ha^{-1}	'Bussard'	'Zentos'
N60	139.2 [a]	113.2 [a]
N90	139.8 [a]	118.5 [b]
N120	147.2 [b]	127.5 [c]
N150	147.5 [b]	131.2 [d]
$LSD_{0.05}$	2.1	1.7

The means in columns marked with the same letter did not differ significantly ($p < 0.05$).

Grain protein content significantly varied depending on the cultivars and nitrogen fertilizer as previously observed (Jablonskité-Raščé et al., 2012; Chope et al., 2015).

In the current research nitrogen fertilizer significantly increased protein content for both cultivars. The greatest content of protein was detected in the grain of both cultivars grown in the plots fertilized with N150. Protein content in 'Bussard' grain in all N fertilized plots was high and can be used for lower quality grain improver, while 'Zentos' only in plots fertilized with N120 and N150 corresponded to required quality for bread making.

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INFLUENCE OF BIOLOGICAL PRODUCTS ON THE GROWTH AND DEVELOPMENT OF MAIZE UNDER GREENHOUSE CONDITIONS

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Agriculture is becoming more and more intense and farmers should take care of the soil, restore its fertility. One of the options is to use biological products, because different microorganisms are vital components of the soil. They mobilise nutrients, produce plant growth regulators, protect plants from phytopathogens, improve soil structure and degrade xenobiotic compounds (Ahemad, Kibret, 2013; Mercado-Flores et al., 2014). The use of biological products results in the higher biomass and seedling height of maize. It also improves organic matter content and total nitrogen (N) in soil (Wu et al., 2005).

The aim of the experiment – to find out the effectiveness of biological product for maize growth in three different substrates under greenhouse conditions within 7 weeks. The research was carried out from 9th of April to 26th of May, 2015. Maize seeds were treated in three different ways: 1 – control (not treated), 2 – treated with biological product, 3 – treated with biological product, fulvic, humic acids, 4 – treated with biological product, amino acids and seaweed extract. Maize seedlings were grown in three different substrates: sandy loam, clay loam and peat substrate. The research results have revealed differences in maize green mass, root mass, height, chlorophyll index, area of the leaves and dry matter.

Maize green mass was higher when seeds were treated with biological product, fulvic and humic acids, therefore, root mass was higher when seeds were treated with biological product, amino acids and seaweed extract. It is noticed that the use of biological compounds have a positive influence on maize chlorophyll index (Fig.).

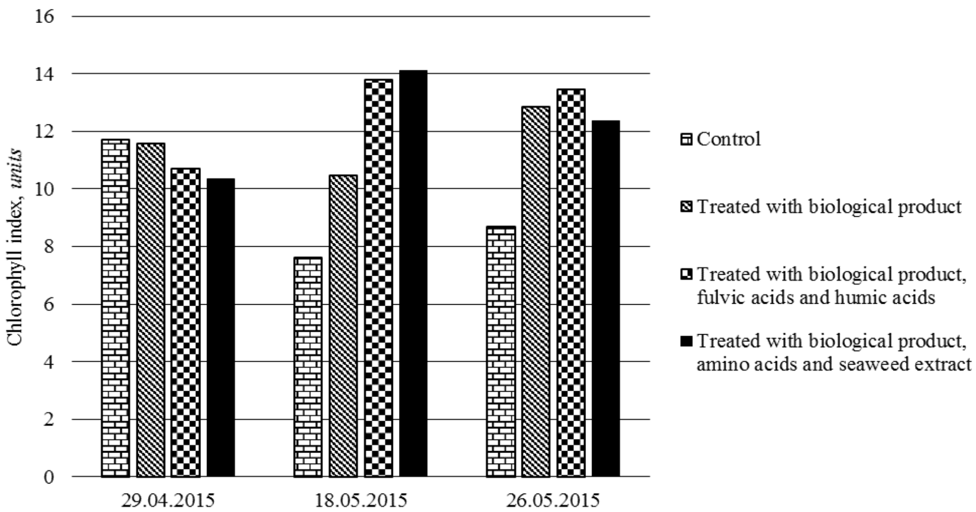

Fig. Variation of chlorophyll index during the growth of maize in sandy loam.

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THE OCCURENCE OF POTATO TUBER SILVER SCURF (*HELMINTHOSPORIUM SOLANI*) AS AFFECTED BY DIFFERENT FARMING SYSTEMS

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Silver scurf (SC) (*Helminthosporium solani* (Durieu & Montagne)) is a potato (*Solanum tuberosum* L.) tuber fungal disease that causes a metallic discoloration on the surface of the periderm decreasing tuber quality. In severe cases the infected tubers will lose weight and shrink, due to the excess water loss, causing also economic problems. As there are no SC resistant cultivars available and the pathogen develops resistance against fungicides quite quickly, it is necessary to investigate the impact of different farming systems (FS) on the containment of SC incidences.

Potato (cultivar `Maret`) was a part of a crop rotation experiment (results from 2015) in which red clover (*Trifolium pratense* L.), winter wheat (*Triticum aestivum* L.), pea (*Pisum sativum* L.), potato and barely (*Hordeum vulgare* L.) undersown with red clover followed each other. The experiment consisted of seven FS – four conventional ($N_0P_0K_0$ – control, $N_{50}P_{25}K_{95}$ – N_{low}, $N_{100}P_{25}K_{95}$ – $N_{average}$, $N_{150}P_{25}K_{95}$ – N_{high}) and three organic (Organic, Organic with catch crops (CC), Organic CC with manure (M) (20 t ha^{-1})). The CC before potato was winter turnip rape (*Brassica rapa* sp. *Oleifera biennis*). Seven months after the tubers were harvested, 100 marketable tubers (diameter >35 mm) from each system replication (4 replications) were taken to assess the incidences of SC.

The conventional $N_{average}$ system had significantly less tubers infected with SC compared to all organic and conventional control systems (Fig.). The Organic CC+M system had significantly more SC incidences compared to all fertilized systems.

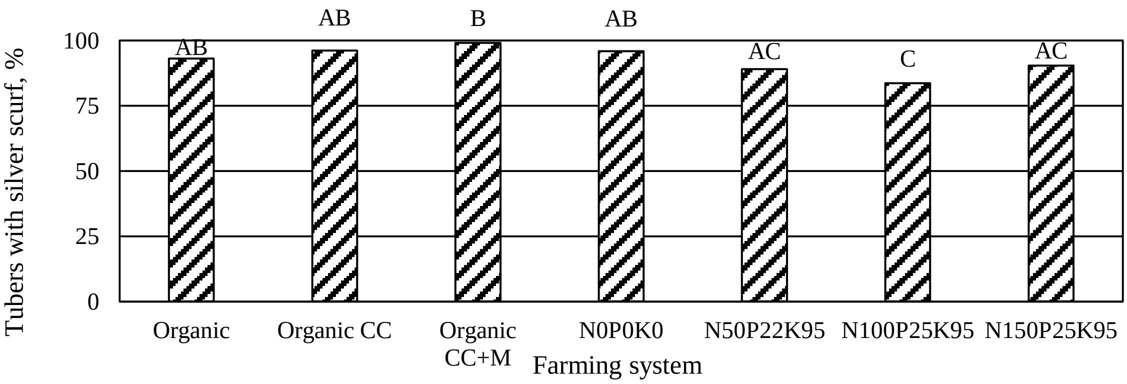

Fig. The average percentage of tubers infected with silver scurf from marketable yield depending on farming systems (FS). Different capital letters on top of the bars indicate significant influence (ANOVA Fisher LSD test $p < 0.05$) of FS.

Although noted before (Tein et al., 2015) with winter oilseed rape (*Brassica napus* sp. *Oleifera biennis*), in this case there was no disease reducing effect when the winter turnip rape was used. Indicating that all *Brassica* species may not have similar impact on reducing SC, disease incidences may depend more on the diversity of soil microbiome. The use of ammonium nitrate in conventionally fertilized systems may biologically activate SC antagonists and thus control the SC pathogenicity and decrease the tuber infections (Martinez et al., 2002).

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LIST OF ORAL AND POSTER REPORTS PRESENTED AT THE 20TH BALTIC AGRONOMY FORUM

Oral reports

Kreišmane Dz. Challenges for future of agricultural science in Latvia.

Gaile Z. Actualities at the Faculty of Agriculture, LLU

Pranckietis V., Blinstrubiene A., Kriauciuniene Z. Research activities at Aleksandras Stulginskis University Agronomy Faculty

Alaru M., Loit E. Pulses in Europe and in Estonia

Alsiņa I., Dubova L., Šenberga A., Zaharāne L., Zīverts K., Liepiņa M. The effectiveness of inoculation of legumes with Rhizobia

Kadžiulienė Ž., Arlauskienė A., Šarūnaitė L. Legumes for sustainability of agroecosystems

Toomsoo A., Teesalu T., Kaevu H., Kriipsalu M., Rossner H., Astover A. Direct and residual effect of organic waste compost on the crop productivity

Ruzgienė D. Development of electronic plant production services for clients.

Karklins A., Ruza A. Fertiliser normatives – adjustment for local soil conditions

Bankina B., Bimšteine G., Ruža A., Roga A., Fridmanis D. Effect of soil tillage and crop rotation on the development of wheat diseases

Mänd M., Karise R. Management of bumblebees to deliver biocontrol agents in open field conditions

Poster reports

Dubova L., Ruža A., Alsiņa I. The influence of tillage on soil microbiological activity

Ausmane M., Melngalvis I., Ruža A. Influence of minimal soil tillage and crop rotation on weed population in crops

Gailis J., Turka I. The phenology of ground beetles (Carabidae) in differently managed winter wheat fields

Mockevičienė R., Marcinkevičienė A., Pupalienė R., Velička R., Kriaučiūnienė Z., Butkevičienė L.M. Earthworm density in spring oilseed rape crop in organic farming system

Jančauskienė I., Blinstrubienė A. Effect of medium composition on *Miscanthus × giganteus* regeneration competence

Vainorienė R., Burbulis N., Blinstrubienė A., Jonytienė V. The effect of potassium bicarbonate on photosynthesis parameters of *Setaria viridis* under drought stress

Bakšienė E., Titova J. Research on the growing of perennial grass for energy

Adamavičienė A., Romaneckas K., Eimutytė E., Kimbirauskienė R. Living mulch and weed competitiveness in maize crop

Lapiņš D., Mintāle Z., Piliksere D., Maļecka S., Ņečajeva J. Information and some results on weed monitoring in the regions of Latvia

Pupalienė R., Jodaugienė D., Sinkevičienė A., Bajorienė K. The effect of mulches on *Elytrigia repens* spreading in organic farming system

Kriauciuniene Z., Cepuliene R., Velicka R., Marcinkeviciene A., Pupaliene R., Kosteckas R., Cekanauskas S. The allelopathic effect of oilseed rape (*Brassica napus*)

Are M., Teesalu T., Kaart T., Selge A., Reintam E. The effect of manure and nitrogen fertilizer on the soil aggregate stability

Raave H. The influence of wood ash on the yield of barley, spring wheat and spring oilseed rape

Bogužas V., Steponavičienė V., Sinkevičienė A. Long-term impact of reduced intensity tillage systems, straw and green manure combinations on soil aggregation, water capacity, pore structure and bulk density

Vaisvalavičius R., Mikučionienė R., Aleinikovienė J., Smalstienė V. Soil structure and organic matter assessment in crop rotation

Masilionytė L., Maikštėnienė S. The effect of alternative cropping systems on the dynamics of the main nutritional elements in the soil

Kosteckas R., Burbulis N. Influence of preparation albit on membrane injury of winter wheat during cold stress

Aleknavičienė L., Staugaitis G., Brazienė Z., Paltanavičius V. The effect of sulphur fertilisation on the yield of spring wheat

Tripolskaja L. Impact of climate variability on precipitation filtration in Lithuania

Peleckis R., Burbulis N. Effect of L-glutamic acid on cold tolerance of winter rapeseed shoots

Loit K., Soonvald L., Runno-Paurson E., Tedersoo L. Arbuscular mycorrhizal community composition of new European potato varieties grown in conventionally treated field soil

Loit K., Kukk M., Öpik M., Runno-Paurson E. Comparison of the extent of colonization of arbuscular mycorrhiza in plant roots in different cultivation practices

Liniņa A., Ruža A. Nitrogen effect on winter wheat grain protein content

Pazareckaitė A., Girdvainytė A., Pšibišauskienė G., Zaleckas E. Influence of biological products on the growth and development of maize under greenhouse conditions

Tein B., Kauer K., Tampere M., Luik A., Loit E. The occurrence of potato tuber silver scurf (*Helminthosporium solani*) as affected by different farming systems

Toom M. Cover crop experiments in Estonia

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