

Research Activities of the Latest Decades in the Faculty of Agriculture

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Abstract. Research activities in the Faculty of Agriculture comprise three main specialisation lines: Field Crops, Horticulture and Animal Science which are associated with other subjects like Soil Science and Management, Grassland, Crops Breeding, Plant and Animal Biology, Plant Protection, Weed Science and Fertiliser Use etc. Traditionally our research strategy is to be engaged in two directions: 1) to provide intellectual services and sound scientific basis for Latvia primary agricultural sector and 2) to incorporate into the interdisciplinary research sector on Latvia, the EU and global scale. Brief overview of activities and results within these spheres is given related to the period starting from 1990 up to now with relevant ideas and propositions for the future prospects. Interinstitutional and international research cooperation and possibility to provide knowledge and services for society are the main pillars of our future development.

Key words: Latvia agriculture, research priorities, agricultural research.

Introduction

In 1992, two faculties – Faculty of Agronomy and Faculty of Zootechnics – were merged and Faculty of Agriculture was established. Three main specialisation lines Field Crops, Horticulture and Animal Science which are associated with other subjects like Soil Science and Management, Plant Biology, Plant Protection, Weed Science, Fertiliser Use were organised within the Faculty. Therefore the main field of research and education was to provide students with competence in the primary agricultural production sector – crop and animal farming. At the same time some part of research activities were related to the environmental aspects, forestry and other sectors through cooperation with other faculties of Latvia University of Agriculture (LLU), research institutions in Latvia and abroad as well. This time was also very important due to the active start of international cooperation. Number of our staff and post-graduate students has a possibility to be involved in different workshops, to attend conferences, and to participate in study courses and short-term on-site training programmes. Besides a number of foreign researchers have visited the Faculty and contributed to our research and teaching activities, and promoted establishment of good professional relationship. It has stimulated our research activities, staff involvement in international research programmes, and expert groups, and has given a good basis for long-term cooperation with international partners.

Our research strategy is to follow the two lines: 1) to provide intellectual services and sound scientific basis for Latvia agricultural sector and 2) to incorporate into the interdisciplinary research sector on Latvia, the EU and global scale. Therefore our contribution and achievements may vary and sometimes it is not easy to determine where our efforts have been more effective either for implementation of small and very practice-oriented tasks or participation in large scale international projects. In general, the latter is good for knowledge and capacity building but the first one – for acknowledgement of our mission and importance for Latvian society.

The period starting from 1990 up to now has been rich in many research-related activities; still it also reflected radical changes going on in economy and social sphere of this country. In the present article we would like to summarise only the main activities and changes, and also to discuss the results that could be important for future developments. The layout of article reflects the main research lines traditionally existing in our Faculty.

Soil science and soil fertility

Soil research obviously has a high importance due to its functions within ecosystem and as a media for agricultural production. Until 1990, the Soviet (Russian) soil science approach and standards were dominating in Latvia. Their differences from the international standards caused real difficulties to use the national soil information outside the country. Therefore the introduction of FAO and the USA methodology of soil diagnosis, classification and information use was one of the research priorities. Series of field and

laboratory studies of for application of international methodology, compatibility studies of previous data with new ones, and data preparation for international data bases were implemented. These activities were performed in close cooperation with the European Soil Bureau, researchers from Sweden, Denmark, the USA and other countries. As a result Latvia soil information is represented in Soil Map of the European Union, the European Soil Data Base, Global Soil and Terrain Database and Soil Atlas of Europe (Karklins, 2005a; Soil and Terrain ..., 2000; Soil Atlas ..., 2005; the European Soil Database, 2004; The European Soil ..., 1998). We are looking forward to follow up these activities for updating the above mentioned soil databases, development of new applications as well as providing the new established European Soil Data Centre with relevant high quality soil information which may be used for many scientifically and politically important issues on the EU level. The implementation of the EU framework project "Environmental Assessment of Soil for Monitoring" (2006-2007) related to the development of unified indicators for assessment of soil threats, risk zones and degradation feasibility shows recent development of these activities. This project coordinated by Cranfield University linked up 37 research institutions across the EU and made significant contribution to common understanding in the sphere of soil protection, harmonisation of monitoring networks, research methods, and information standards.

Soil and land protection and sustainable management, resources inventory, monitoring, data acquisition methods, information use were the objectives of several projects running in Latvia where our researchers were leaders or participants – one of them being "Three Level Agricultural Land Monitoring in Latvia" (1992-2001), which was designed as extensive, and therefore rather expensive monitoring programme. Probably at that time we were not able to draw up strong enough administrative and organisational strategy to fulfil a scientifically interesting and practicably sound programme which could generate the valuable information about anthropogenic impact on Latvia soils and land use pattern. Weakness of political interest led to a gradual decrease of funding, and finally the programme was stopped even without a possibility to process the obtained results. Unfortunately several attempts to re-establish National-wide soil and land monitoring programme did not succeed. Probably the development of modern and economically relevant soil and land monitoring programme with sustainable long-lasting organisational-financial framework is one of the priority tasks of our researchers.

"Building sustainable capacity and ownership to implement UNCCD¹ objectives in Latvia" (2005-2008) financed by the United Nations Development Programme was another more recent but a short term project. This project mainly did not generate new data about Latvia soils or land resources but it served as an attempt to provide an overview about our current situation, future needs and ways for implementing the ideas, transferring knowledge and developing new products and applications in the field of sustainable land/soil management. One of the priorities is to establish a reasonable and effective legal and institutional basis for these activities, and to develop a relevant and long-lasting financing mechanism.

Parallel to the above mentioned activities a research was done (A. Kārklīšs) for the development of Integrated Soil Information System in Latvia. The main objectives were to propose a scheme for soil resources inventory which meets requirements of international standards including soil diagnosis methodology and application of the World Reference Base for Soil Resources (WRB) as a tool for soil classification. Also renewal of national soil classification was planned. These activities successfully were reflected in several publications (Karklins, 1995, 2002, 2007, 2008; Latvijas augšņu ..., 2009).

The future trends are to follow up with research and development in the field of soil and land resources inventory, and the main areas of interest are as follows:

- comparison of the soil units of national (genetic based) classification system with the WRB and vice versa;
- development of methodology for historical soil data transformation into the modern standard;
- development of methodology for soil/land degradation assessment;
- monitoring of changes of soil properties related to the non-traditional use of agricultural land (afforestation, continuous cropping, cultivation of energy crops etc.).

¹ United Nations Convention to Combat Desertification

Another line of research activities is related to soil fertility issues, nutrient flows in agriculture, environmental aspects of manure and fertiliser use, crops' fertilisation strategy and methods. If the period of the 1960-1990s was characteristic of intensive fertiliser use with rather little attention paid to the economic and environmental consequences then the past two decades are continuously stressing these issues and putting them as dominating priorities. The shift has been very sharp due to the economic and political reasons, and thus new developments were very indispensable. Therefore researchers were involved in several international projects like "Agricultural Run-off Management Study in Latvia" (1992-1993), "Development of Code of Good Agricultural Practice for Latvia" (1999), "Improvement of the Fertilising Normative – especially Manure Standards" (2001-2002), "Managing Inputs of Nutrients to Avoid Insufficiency or Excess" (1998-2002), and national projects like "Fertilisation Optimisation According to the Principles of Good Agricultural Practice" (2001-2003) etc.

These activities (A. Kārklīš, I. Lipenīte, R. Vucāns) are related to the development of fertiliser and manure use environmental risk assessment methods as well as recommendations for implementing the propositions drafted in the Code of Good Agricultural Practice; for accumulating of experimental data necessary for the development of agronomically, economically and environmentally sound fertilisation schemes; for the development and validation of the models for environmental risk assessment, e.g. plant nutrient balance, manure outcome and chemical composition calculations applicable on-farm level, yet compatible with the EU requirements (Karklins, 2005b; Karklins, Lipenite, 2005).

Implementation of the EU Nitrate and Water Framework directives, HELCOM recommendations, the Code of Good Agricultural Practice, and similar strategic documents require relevant national-based methodologies and various normative values. As most of them should be obtained experimentally investment for such research is tremendous. Therefore an attempt to coordinate all agronomical experiments which could contribute to any valuable data necessary for meeting the above mentioned objectives is undertaken. However still a number of high priority topics like nitrogen, methane, and carbon emissions from agricultural land and animal operations, carbon sequestration, nutrient leaching etc. practically are not studied based on solid experimental approach. Actually it is a fundamental science not fitting into the short-term project framework dominating nowadays in Latvia.

Plant and soil biology

Long-term investigations of symbiotic nitrogen fixation, nodule formation, and effectiveness of inoculation were carried out at the Department of Plant Biology under the guidance of prof. V. Klāsens. Occupancy and symbiotic features of *Rhizobium leguminosarum* in Latvia's soils have been determined (V. Klāsens, I. Januška, A. Anševica) during the past two decades. The academic staff has established the main environmental factors effecting nodule formation, *Rhizobium* occupancy in host plant roots, effectiveness of nitrogenisation, and their effect on legume yield formation and its quality (V. Klāsens, B. Mārka, V. Šteinberga, I. Alsina, S. Ošlāpa). The obtained results showed that the yield increase was determined mainly by the characteristics of the soil and less by the biological features of symbionts. Therefore one shall distinguish the terms potential and real effectiveness of nitrogenisation. Streptomycin resistance (V. Klāsens) and genetic identification (L. Dubova, A. Anševica) of *Rhizobium* strains are used. Collection of an active *Rhizobium* strains (approximately 40) is maintained, examined and passed to farmers.

Determination of soil biological, microbiological, and enzymatic activity was carried out during the past decade (L. Dubova).

Regulation of plant growth and development, yield formation and its quality are the main interests of the teaching staff dealing with plants. The effect of illumination and light spectra on seed germination (V. Klāsens) and plant growth (I. Alsina) has been examined. Researchers of the Department have investigated the effect of environmental factors on the quality of grain (V. Klāsens) and vegetables (I. Alsina, A. Bāliņš).

An active cooperation with universities and research institutions in Sweden, Finland, Russia and the United States of America has resulted in joint publications, scientists exchange and research activities.

Two doctoral theses (V. Klāsens – Dr.habil. agr., and I. Alsina – Dr. biol.), 15 master degree and 70 bachelor, and diploma papers have been developed and defended during the past two decades.

Soil tillage, weed control and precision field management

Weeds biology and control. The main research was devoted to the development of methods and testing of new herbicides which have appeared relatively recently, spread out intensively, and are used for weed control. Also following the environmental consequences and attempt to reduce the use of different chemicals including herbicides, some research was performed with its low-rate application. Therefore our research was devoted to the development of recommendations for wild oat (*Avena fatua* L.) control in spring barley fields as well as optimisation of weed control for sugar beets grown on sod calcareous loamy soils (Lapiņš, Bērziņš, Rubenis u.c., 1998; Korolova, Lapinsh, Berzinsch, 2000).

Application of reduced herbicide dosages on weed infestation was studied for spring barley. The post-effect of reduced herbicide dosages on weed's next generation was studied as not only the first year effect, but also weed survival and its distribution afterwards is important. It was done in vegetation trials in Denmark using goosefoot (*Chenopodium album* L.) as a test plant (Kopmanis, 2005).

Distribution of invasive weed species *Heracleum sosnowskyi* Manden is a great problem for Latvia. Initially it was introduced in the 1950s for forage production, though very soon it distributed and ran out of the control. Presently we are participate in the assessment of its distribution and development of recommendations for mechanical, chemical, biological and integrated control of the mentioned weed species (Bērziņš, Ojukalns, Lapiņš u.c., 2003).

Our long-term research activities are connected with monitoring of weed infestation in crops. Some observations performed in permanently erected monitoring plots in Kurzeme and Zemgale regions showed that some weed species have totally disappeared during the past 50 years, and special measures have to be initiated to protect biodiversity of local gene pool. Results show that growing of cereals prevailing in these regions and usage of herbicides has increased distribution of pansy (*Viola* spp.), wild buckwheat (*Polygonum convolvulus* L.), and speedwell (*Veronica* spp.) compared with the area where herbicides were not used. High level of infestation with weeds was observed also in perennial grasslands, where many of weed species are poisonous for domestic animals (Korolova, Lapinsh, Berzinsh, 2006; Lapinsh, Korolova, Berzinsh, 2008).

It was observed that in a sowing year of perennial legumes (red clover, white clover, alfa-alfa and fodder galega) as well as in the first production year of grasses tank mix of herbicides pendimethalin and bentazone provide the highest effect. Some negative effect of chemicals on leguminous plants was observed but it was compensated by the yield increase. Phytotoxicity of herbicides mainly was influenced by soil type and texture but less by species and variety of legumes. Phytotoxicity of herbicides MCPA, bentazone, amidosulfuron and tribenuron-methyl differed also among perennial grasses grown: cock's foot, perennial ryegrass, meadow foxtail, timothy and meadow grass. Herbicide MCPA showed relatively lower impact on cultivated grasses. The study included also the ability of competition between cultivated grasses and weeds. Different species of perennial grasses show different competition ability with weeds in the year of sowing. Post-effect of herbicides in the first production year of perennial grasses showed an increase of yield and a decrease of number of weeds in crop stands (Lapiņš, Bērziņš, Adamovičs et al., 2001).

Soil tillage. A long term stationary trials for optimisation of soil tillage systems in cereals-grasses crop rotation in sod calcareous soils were started in 1982. The experiment included the comparison of traditional annual ploughing, periodical ploughing, and minimal tillage as well as deep loosening technologies. Results showed that annual soil ploughing in six-field crop rotation could be replaced by one ploughing per crop rotation period without significant yield decrease; in other years ploughing was replaced by shallow ploughing at the depth of 10-12 cm (Kroģere, Liepiņš, Ausmane et al., 2005).

In trials for investigation of soil tillage-drilling technologies for winter wheat and spring barley experiments showed that soil deep loosening gave higher positive effect for winter wheat than for spring barley. Deep soil loosening before winter wheat drilling showed positive effect on wheat grain yield also in the repeated sowings. Significant influence of chisel ploughing on soil resistance was established only in the place of

action; in the rest of soil volume the resistance did not change or even increased. Direct drilling without soil reversing significantly decreased the yield of spring barley, yet it increased for winter wheat. Autumn application of glyphosate reduced the difference between treatments of spring barley drilling methods (with and without soil reversing). Soil moisture at the depth of 0–45 cm was significantly lower in plots covered by plants in dry-season years, and made substantial lack of water at the spring barley tillering stage and after it. It was accompanied by significant higher soil resistance in spring barley sowings. The relationship between soil moisture and soil resistance can be described by linear correlation, while among soil moisture, soil resistance and grain yield – by multicolinear coherence (Lapins, Berzins, Kopmanis et al., 2005a, 2005b).

Precision field management. Precision field management technologies gain growing popularity among Latvia farmers. Therefore the adaptation of equipment available on market, its evaluation and recommendations for its use are relevant. The main objective of research was to find scientific explanation for differences of soil tillage in fields with uneven soil pattern and fertility. It was concluded that humus content and the depth of topsoil were the most significant factors which should be taken into account for differentiation of soil tillage for winter wheat. GIS cartograms give the possibility to decrease the depth of soil tillage in particular field spots, if the depth of topsoil is deeper than 36 cm. The mentioned feature was observed in 60% of the whole field area. It was realised that soil resistance above 600 kPa cm⁻² in subsoil significantly reduced the yield of winter wheat; although the cartogram of soil tillage differences allowed the decrease of the total area for soil deep loosening by 48%. Trials to prepare weed infestation cartograms for differentiation of herbicide dosages were carried out. Significant influence on field elevation, the depth of topsoil and humus content to soil moisture in topsoil and below it was obtained in all treatments with and without soil deep loosening. Soil moisture effected the soil resistance in all soil layers up to 50 cm from the soil surface in both treated and non-treated plots. The analysis of yield maps did not verify the positive effect of soil deep loosening on winter wheat grain yield in the first year after tillage, while in the next year (due to more rainfall) treatments with soil deep loosening gave significantly lower winter wheat grain yield. (Dinaburga, Lapins, Berzins et al., 2008; Dinaburga, Lapiņš, Bērziņš, 2009).

Plant protection

Starting from the 1990s the main research problem was to introduce the integrated approach for plant protection oriented on small size (compared with the previous period) farming units, generally private farms. One of the research objectives was to introduce the new system, for forecasting and warning against crop destructive organisms, using new forms of organisation and including information technologies and Internet services. Pathogens and pest's damage thresholds and criteria were studied, and software for forecasting of cereal and potato diseases and pests were developed. To minimise the pesticide use for field crops and to produce the agricultural products more ecologically friendly experiments were focussed on Integrated Plant protection strategy. The PC software was developed where pesticide usage was adjusted based on studies about the pest and disease biology, cultivars resistance and weather influence. The PC models NegFry and PC-cereal diseases which are the intellectual property of Danish Institute of Agricultural Sciences were used in co-operation with their authors.

Wherewith, a wide research of biology and epidemiology of the potato late blight *Phytophthora infestans* and other potato diseases was carried out. The oospores were found in 80–94% of the investigated cases. Potato leaflets with two or more separate spots are the samples were oospores could be found on the field conditions in Latvia. Many potato leaflets with two spots were observed at the end of a growing season when the disease severity exceeded 50%. The occurrence of oospores means that potato late blight control might be performed by crop rotation and the use of certified seed material; and the usage of fungicides may not be effective.

Models were introduced in Latvia on the basis of the study of development of major crops and pathogens, motivation of pesticide usage, choice of pesticide dosage and its optimisation, optimal intervals between spraying, and design of database according to unified scheme.

Wheat leaf diseases are the most important diseases of wheat. Detailed understanding of pathogens populations' structure and biological peculiarities of pathogens life cycles is necessary for integrated plant protection. Existence of *Pyrenophora tritici-repentis*

teleomorph (pseudotechia with asco spores) on the straw after over wintering were confirmed and described for the first time in Latvia.

Sharp development of snow mould (caused by *Microdochium nivale*, previous term *Fusarium nivale*, teleomorph *Monographella nivalis*) was observed in 2005-2007. Crop variety is an important factor affecting snow mould infection. The main reason of sharp development of the disease is too early sowing time of winter wheat. Uncommon meteorological conditions (long and warm autumn) served as the main reason for unexpected development of snow mould.

Ergot of triticale and rye (caused by *Claviceps purpurea*) is a widespread disease, it is not possible to control the disease by fungicides, and therefore the influence of different agroecological factors was investigated. Optimal crop management is important to avoid ergot occurrence in rye and triticale. More sclerotia were found near a field margin (>1 m) in comparison with the zone more deep in the field. Sclerotia germination was noted in the beginning of May, but perithecia with asco spores developed considerably later; therefore an infection is possible for a longer period – from the end of May to the end of June. Development of diseases becomes one of the most important risk factor for oilseed rape cultivation on the conditions of intensive management. Phoma stem canker (caused by *Leptosphaeria* spp., anamorph *Phoma lingam*) is one of the most important diseases of oilseed rape over the world, also in Latvia. Different symptoms on the leaves colour and morphology of pure cultures confirmed the occurrence of *L. maculans* and *L. biglobosa* in Latvia. Teleomorph of pathogen was found for the first time in Latvia, and identification of species has been done for the first time in the Baltic region.

In recent years, particular attention is also paid to the research that relates to the possible cultivation of genetically modified (GM) crops in Latvia, their economic importance and problems. Due to the small territory of the country and scattered fields all around the country, it is not possible to find the specific regions where only GM crops could be grown in Latvia. According to the data available by Latvia Rural Support Service, rape and potatoes are grown all over the country and rapeseed areas are also rapidly increasing. GM Bt maize cultivation which is resistant to pests, is not an issue in Latvia, since we have no specific maize pests. In Latvia where relatively small fields dominate, pollinating insects transfer pollen from the GM fields to the conventional and biological ones contaminating honey with GM rape pollen; and therefore production of certified organic honey becomes impossible.

One of the most important co-existence requirements is to define the separation distance of 4000 m for fully fertile GM rapeseed from its conventional and/or organic congeners. The problem is that additional costs arise from the compliance with management and inspections. The deficiency of basic information on the state of ecosystem before expansion of genetically modified organisms (GMO) in the environment is one of the essential problems in risk evaluation in Latvia. Economic analysis of growing conventional and GM rapeseed was performed.

Crop science and grassland management

Similar to other branches the Department of Plant Production took an active part in elaboration of normative documentation for the re-established country at the beginning of the 1990s. The first regulations for seed production, and normative and methodological standards concerning seed quality were worked out by the Department. A. Ruža together with his colleagues (A. Adamovičs, J. Lauva, V. Ruža) prepared a scope of standards, normative documents and methodological guidelines for seed and grain as well as they were involved in the elaboration of different provisions, regulations, and legislative initiatives (*Plant Protection Act*, *Seed Act*, etc), that were developed and harmonised according to the EU regulations.

Animal production was developed as key industry and field crops were grown mainly for fodder supply before the 1990s. Hereby technological issues and quality standards mainly were focussed on that issue. The grain was grown also as a source for human food; therefore other quality aspects became outstanding. Thus the necessity to develop integrated standards for assessment of grain quality was topical. Considering common development tendencies in plant production, the changes need to cover not only narrow technical aspects but the whole system including the research.

Numerous field trials were performed on all varieties grown in different soils and various regions of Latvia until 1990. However, the majority of investigations were practically oriented and aimed to fulfil the main demand in that period – increase of

yield production. Comparatively small amount of theoretical studies was done that might provide the usage of experimental results for the new situation. After the 1990s, a number of field trials decreased dramatically but the remaining were reorganized to meet the changing requirements. Quality parameters, economic consequences, performance of new varieties, fertilisation, plant protection aspects, and environmental aspects etc. were the main issues for cereal research. The new varieties of intensive or very intensive type were introduced in the past and present, having specific cultivation requirements as well as new machinery was introduced. All together it gives the new challenges for crop cultivation science.

Comparatively wide scale field trials with different species of cereals and grasses were provided. Effects of different meteorological and soil conditions, mostly for the influence of fertilisation with nitrogen, on the yield quality indices were revealed. Protein content and Zeleny index or sedimentation value (SV) as protein quality indices, apart of gluten content, and especially gluten quality, are accepted as the main quality criteria in the European Union and in other Western countries. Unfortunately, no investigations were performed on these quality criteria until 1997. The aim of our first investigations was to clarify an influence of various soil and meteorological conditions on different winter or spring wheat yield and grain quality indices complex development process, correlation relationship between quality parameters, most important influence factors, stability of genotypes of variety, possible deviations of face value in different meteorological conditions, and growing media. Investigations clarified the influence of agro-ecological conditions on winter wheat quality indices, and showed that the average yearly meteorological conditions were the major factor influencing gluten content and its quality for all varieties investigated. It is necessary to select varieties having most stable gluten content and gluten index for all introduced varieties in varying meteorological conditions for production of qualitative food grains from winter wheat. Nitrogen *rates* cannot be appointed equal in every following year, but *fertilisation* should be differentiated in dependence on vegetation period of variety, its potential crop productivity, foregone range of qualitative indices, and characteristics of vegetative period principally. Investigations of such a type were coordinated between the research institutions of Latvia that gave possibilities for more effective use of material resources, laboratory equipment, and, most important, the obtained results are comparable for different regions of Latvia.

Investigations done on a regular basis on seed long-term storage and providing inspection of seed quality parameters (germination, seedling vigour, growing intensity of germs, and shoots) revealed that the less decrease in germination of seeds was obtained for oats with some deviations amongst varieties, while the type of storage has a significant influence on germination parameters for other species with respect to storage type over a span of 10 years period. A decrease of germination was most affected by storage in special chamber. Germination was lost completely for rye and summer barley after a 10-years storage period. Germination was similar, but with less decrease of germination, for seed stored in jute sacks on usual conditions. The best results (except rye) were obtained for storage in hermetic plastic bags. Therefore cereal seeds (except rye) stored in hermetical plastic bags can maintain stable germination over 85% during a 5-10 years storage period, if previously the seeds are dried up to 10% moisture.

Wide, complex investigations in the grassland management and forage production areas were provided under the guidance of Prof. A. Adamovičs. Important information was obtained, based on the results of field trials and laboratory analyses, on the following issues: competition between legumes and grasses, and interaction in grassland agro-phytocenosis, characteristics of photosynthesis process in different agro-phytocenosis, biomass accumulation and quality development for different species in various agro-phytocenosis, overground part pattern along layering horizons in different agro-phytocenosis, energy value of yield obtained from different species and agro-phytocenosis, plant nutrient off-take with a yield, the post-effect of different grasses and mixed swards on quantity and quality of grain yield. The data obtained serves as the basis for next stage – elaboration of theoretical models for the development of field crops quantity and quality.

Research programme has been started on the possible use of field crops for production of renewable sources of bioenergy (biogas, bioethanol, and solid biofuels) (Adamovics, 2007).

Investigations on plant breeding and seed farming were provided under the guidance of Prof. I. Belicka. Scientific investigations were provided within the framework of several projects financed by the Ministry of Agriculture and the Scientific Council of Latvia. Number of students were involved, and 45 graduation papers were prepared based on the studies of morphological features as criteria for selection of elite plants and perspective plant lines, studying the resistance of varieties to different diseases, comparison studies of barley varieties suitable for Latvia climatic conditions, etc. Special work was accomplished by cultivating barley lines with high protein content, crossbreed of hull-less barley varieties, and developing of hull-less barley selection in Latvia. Work was provided also in breeding of winter wheat evaluating the quality of awned and awnless wheat lines. As a result varieties of summer barley 'Klinta' and 'Malva', and wheat variety 'Moda' (Otto) were developed. Three doctoral theses were presented under the supervision of I. Belicka.

The research results of are presented in publications of the Department of Plant Production and Institute of Agrobiotechnology (Adamovics, Adamovica, 2007, 2007, 2008, 2008; Balodis, Gaile, 2008a, 2008b; Belicka, Legzdina, 2001, 2002a, 2002b; Gaile, 2008a, 2008b; Gutmane, Adamovics, 2008; Ruza, 1997; Ruza, Karele, 1999; Ruza, Kreita, 2008; Ruza, Adamovics, Bankina et.al. 1994; Ruza, Adamovics, Bankina et. al. 2004; Kronberga, 2008; Kunkulberga, Ruža, 2008; Linina, Ruza, 2004).

Horticulture, apiculture, and vegetable production

The Department of Horticulture carried out their research in four main directions – fruit production, vegetable production, ornamentals, and apiculture. At the beginning of the 1990s one of the main research topics carried out was cranberries (*Vaccinium oxycoccus* L.) – European or local Latvian forms. Comparing with the American large berry cranberries, the advantage of ours was a shorter growing cycle and an improved quality of berries. It was worked on the breeding direction. Both the physical and chemical mutageneses were used for breeding a highly productive wild clones. In the nursery of the breeding material, 172 cranberry genotypes were studied, most of which were collected in Latvia and part of them – in Estonia and Russia. Clones derived in the breeding cranberry were tested for growing on crop conditions and recovered bogs. Some research was carried out on the propagation of the best genotypes by hardwood and softwood cuttings, planting establishment, plant density, substrates, morphological, and biological properties of plants, etc. This research led to the selection of several most valuable clones – V-63583, V-63383, B-83 etc. that gave the highest yield and berry quality (Gronskis, Liepniece, 2004).

The research with the newly introduced variety of the American large berry cranberries (*Vaccinium macrocarpon* Ait.) was commenced in 1985. Due to the favourable climatic conditions in Latvia and huge areas of the high moss peat bogs, opportunities opened for commercial areas to grow the new crop there. Currently 100 ha have already been planted by the large berry cranberry plantations, and Latvia takes the third place worldwide. Plantations of the highbush blueberries are close to 200 ha (Abolins, Gurtaja, 2006; Abolins, Liepniece, Sterne, 2009).

Alongside with the large berry cranberries, *Vaccinium* variety – the highbush blueberries were investigated as the second introduced from the USA. Visiting 19 enterprises and farms in four fruit-growing zones of Latvia dealing with cranberry and highbush blueberry cultivation included the study of the varieties of large berry cranberries and highbush blueberries, their physiological condition after the hibernation period, the production technology, features of the location, yield, and quality. A research was also carried out on the propagation of the highbush blueberries by softwood cuttings (M. Āboliņš, M. Liepniece, D. Sterne, R. Sausserde). Plant nutrition trials were carried out in cooperation with researchers from the Laboratory of Mineral Nutrition of Plants at the Institute of Biology the University of Latvia.

The second research direction was qualitative breeding of the planting material using a variety and rootstock combinations. The research was carried out within the framework of the research project "Development of Sustainable Systems for the Production of Fruits and Vegetables" and carried out together with Pūre Horticulture station (2001-2004), and the project "Development of Technologies of the Horticulture Products and Quality Model on the Agro-ecological Conditions of Latvia" (2005). The best graft combinations were found (Abolins, 2004; 2006) as a result of these projects.

Research is carried out in cooperation with Latvian State Institute of Fruit Growing on the gene pool of berries, mostly, black currants, and their usefulness in the selection. As a result, a researcher K. Kampuss has defended his doctoral thesis "Research of Black, Red, and White Currant (*Ribes* L.) Genetic Resources in Latvia". Currently, new doctoral researches are being carried out by D. terne "Temperature Influence on the Winter Hardiness and Productivity of the Highbush Blueberries (*Vaccinium corymbosum* L.)" and by D. Feldmane "Influence of Irrigation and Chip Mulches on the Sour Cherry (*Prunus cerasus* L.) Production and Fruit Quality".

In apiculture, the main direction of the research is conservation and selection of genetic resources of Latvian local honeybee (*Apis mellifera*) as part of Latvia's fauna. Latvian local honeybee excels with very good hibernation ability in the climatic conditions of Latvia, but there is a need to eliminate such unwanted signs as an extra aggression and swarming proclivity in the selection process, thus, building resistance to diseases and raising productivity of honey. The training and research farm of horticulture and apiculture of the Faculty is the only place in Latvia dealing with the research and selection of Latvian local honeybee using the instrumental insemination of queen bees. In collaboration with Latvian Apiculture Society, the research is carried out on the development of honeybee breeding. Apiary tested systems are used for its development. So, for instance, bee hives rating systems, morphological analysis systems etc. are included in the programme of the honey bee breeding documentation. It should be noted that honeybee breeding has not existed until now in Latvia. Thus, the whole system is built from the scratch (A. Krauze, V. Brusbārdis).

The research carried out in the ornamentals is mainly market-orientated. Growing of different ornamental trees and shrubs in containers was studied. Research was carried out on the ornamental plants for different types of inoculation as well as the aquatic breeding and cultivation technologies. The research is also carried out on the mixed farming system, and evaluation of the planting stock of the ornamental trees (A. Dižgalve, M. Liepniece, A. Bērziņa, A. Balode, R. Sausserde).

The ongoing research in vegetable production which was started in the earlier periods was continued also in 1990 with different changes and additions. Latvia became an open market and less known vegetable varieties rapidly went into our farms. Therefore, in the beginning of the 1990s, one of the research directions was related to the research of these species with the aim to develop an agro-technical package of measures to ensure early and total yield as well as quality of the standard level in Europe, thus, minimising manual work. Under the guidance of Prof. M. Baumane and K. Dzērve, trials were established to study the properties of the new varieties and hybrids, their suitability to specific growing conditions and the aims in order to choose the best-fitting technology for a high-quality output.

The project "Use of the Local Gene Pool for Conservation and Development of Vegetable Varieties Suitable to the Ecological Conditions of Latvia" was launched by the Department of Horticulture in 1997. Within the framework of the project, research was carried out on identification, restoration and the cucumber gene pool, and on the establishment of new parent plant lines for the production of new hybrids. The research was concluded with L. Lepse doctoral thesis "Using of the Morphological Criteria and Molecular Markers in Renewing of the Cucumber Variety 'Dindoņa Zajie Ķekaru'".

In the middle of the 1990s, research was started on the development of agro-technics for commercial herb cultivation (I. Žukauska). The aim of the research was to develop criteria for risk factor reduction at the critical stages of growing herb species. The research findings are published and reported in conferences.

Identification and evaluation of genetic resources, study of factors favouring the diversity of wild plants and formation of collections take a growing role on the international level. With the increase of interest in the genetic material of herbs and medicinal plants in Europe, in 2000 with the aid of the gene pool of the Nordic Countries, an international cooperation project "Culinary Herbs and Medicinal Plants in the Nordic and Baltic Countries. Conservation Strategy of the Genetic Resources" was launched. The aim and assignments of the project are to develop a strategy *in situ* and *ex situ* for conservation of herbs and aromatic plants, creation of collections or their supplementation, characterisation of the collection by descriptors developed by the project participants, and strategy for conservation of species. Within the framework of the Nordic Gene Bank and the cooperation project of the Baltic Countries, descriptors for the species *Origanum vulgare* L. and *Thymus spp.* L. are developed (I. Žukauska).

Since 2005, the programme supervised by the Ministry of Agriculture "Genetic Resources of Agriculture and Food, Livestock, Forestry and Fishery in the Programme of the Sustainable Use of the Long-term Conservation" is being implemented. Projects are implemented on the conservation and research of the genetic resources of the aromatic and medicinal plants, obtaining high-grade, safe and healthy food products derived from genetically, physiologically, and bio-chemically diverse plant material. Evaluation and selection of the genetic diversity of oregano (*Origanum vulgare* L.) and thyme (*Thymus ssp.* L.) species are done in relation with the physiologically active substances in their composition (I. Žukauska).

The research of the genetic resources applies the method of the molecular markers more and more widely, e.g. for studies of the diversity of Latvian aromatic and medicinal plants (A. Balode).

In the vegetable production, research is carried out on the effect of physiologically active compounds on the growth and development of vegetables, and enrichment opportunities of vegetables by mineral elements which are deficit in Latvia (I. Alsija).

Animal breeding

Research provided by the teaching staff of the Department of Animal Breeding (existing in LLU up to 2005) was represented by a range of investigations that belonged thematically to several directions and periods. Investigations in general outline the choices and characterisations of animal traits needed to provide the selection process as well its usage for implementation of pedigree and selective programmes.

First direction relates to the choice of animal traits, estimation of measurement and characterisation potentialities paying a special attention to the assessment of quality of lamb carcasses, quality of growing, and immunological traits (D. Kairiša).

Another important direction was the research of economically beneficial animal traits, aimed to investigate cow's individual milk production characteristics and parameters. Research on individual milk production was started with the investigations of lactation persistency. Factors influencing the concentration of lysozyme, stability aspects of milk production, variability of features as well as the influence of intermediate stage between parturition on individual productivity were investigated in the process of milk production. Freezing-point of milk and different milk composition parameters were investigated according to the interests of production quality controlling body (D. Jonkus).

In poultry farming the following items were investigated: influence of plant additives on production quality, morphological traits of eggs, correlation of traits in cross-breeding, relationships between chicken feeding and their productivity, and specific features of poultry production in Latvia (J. Nudiens).

Principles of usage of herd-book were analysed in Horse-breeding sector, investigations were provided on horses exterior and working capacity, assessment was performed for the results of genological analyses, and a pedigree programme was elaborated for horse population in Latvia (G. Rozītis).

Investigation of methods for assessment of genetic value of animal traits.

Investigations on linear statistical models were started in the last decade of the former century aimed at defining assessment models for bulls that should be most suitable on Latvia conditions. Factors influencing cows' productivity have to be revealed as well as factors with most substantial proportion should to be included in the model used for valuation. Dispersion components were determined by means of computer software LSMLMW and MTDFREML, and then used for further calculations of genological values. A software VCE was used for the estimation of genetical and phenotypical parameters. A computer software PEST was used for animals breeding value estimation. Both "father" and "animal" models were used for the assessment of cows. Linear statistical models for milk livestock assessment, particularly, applying BLUP 'animal' model, in the first stage of investigation resulted in a doctoral thesis elaborated by L. Paura in 1999. Further investigations using linear statistical models were connected with the necessity of transition from standard cows lactations data to "test-day" data use. Work was completed in 2008, when R. Zutere upheld her doctoral research.

Methodical aid for the establishment of selection programmes in milk cattle-breeding was worked and used for training of students and elaboration of selection programmes for specific populations. This computer software was improved in the Laboratory of *Quantitative Genetics and was named as "ZEVS10"* (Z. Grīslis, V. Kižlo, E. Jeņikejeva). Findings were continued aimed at making some parameters of model more accurate, and

researchers presented information in scientific conferences on the elaboration principles of animal breeding programmes in Latvia.

Conservation of genetic resources of domestic animals in Latvia. In respond to call of FAO to participate in the preparation of the world's first Report on situation with *genetic* resources of animals, the *Ministry of Agriculture of the Republic of Latvia organised Advisory Committee of Pedigree Animal Genetic Resource Maintenance and Working group that prepared a report in 2003*. Project coordination was performed by our *Laboratory of Quantitive Genetics with the participation of M. Līdaks, R. Beķere, A. Veģe et al.* Organised work in connection with the conservation of genetic resources in Latvia actually started only in 1995 with the measures of Latvian Blue cow breed maintenance. The foundation of Data Processing Centre starting its activities in 1997 served for positive improvement information acquisition on domestic animals breeds. Vital role in updating animal genetic resource research and preservation work during the last decades of the 20th century were practical initiatives supported by the Nordic Council of Ministers and practically organised by the Nordic Gene Bank of Animals in the Baltic countries. In 2000 the Ministry of Agriculture established a work group of specialists who developed the first version of Domestic Animal Genetic Resource Maintenance and Research programme. The programme defined 5 protected domestic animal breed populations in Latvia – these breed populations were established in Latvia in the historical time: Latvian Brown and Latvian Blue cows, Latvian White pigs, Latvian Horses (draught horses), and Latvian Dark-Headed sheep.

Molecular genetic methods in animal breeding. Proposition in the usage of molecular genetic methods in breeding work was given by the participation in Project "EURO-CAD" of the Nordic and Baltic countries, guided by the Nordic Gene Bank of Animals that was performed by the participants from Norway, Finland, Estonia, Lithuania, and Latvia in the period of 2000-2003 (a coordinator from Latvia – Z. Grīslis). The main objectives of project – use of *microsatellite* DNA marker method (20 *microsatellites*) for investigation of *genetical diversity and similarity, and origin of cow population in the Nordic and Baltic countries*. Biomaterial (blood) samples were obtained from 3 Latvian cow breeds: Latvian Blue, Latvian Brown, and Danish Red in Latvia. Sheep populations were analysed separately. Analyses were taken from Latvian Dark-Headed sheep.

Since 2006 the implementation of molecular genetic methods became more realistic in our Faculty, and equipping of the Laboratory of Molecular Genetic Investigations was started. The main task of the Laboratory is investigation of domestic animals at molecular level and obtaining the characteristics of *genetic* resources.

Since 2007 wide scale scientific activities have been ongoing in the Laboratory of Molecular Genetic Investigations. Close collaboration continues with the Laboratory of Genomics and Bioinformatics from the Faculty of Biology, the University of Latvia, resulting in possibilities to publish number of scientific papers on *myostatin gene*. In 2009, a 4-year project was started, aimed at investigating polymorphism of milk protein genes within Latvian cow populations, and also at preparing information needed for transition to GAS (gene assisted selection) in our milk cow populations.

Animal nutrition

Under the guidance of Prof. J. Latvietis, the Department of Animal Nutrition worked out animal nutrition standards for control and rationing daily ration settings on the increased (20-30) criteria number as well as recommendations for the use of the standards were developed; at the same time cows, pigs, sheep, and horse feeding rations were defined using computers (J. Latvietis, L. Kārklā, J. Ozols et al.). The standards gained popularity among practitioners. Due to their popularity, the standards were repeatedly published for different breeds of cattle until the end of the 1990s.

Extensive scientific studies were carried out explaining: a role of microelements in animal nutrition (I. Rūvalds, J. Lielais), and an effect of using different biologically active substances in nutrition of farm animals and poultry (S. Zaharčenko, U. Osītis, L. Kārklā). At the same time the research was done giving biological and zootechnics assessment for new, non-traditional feeding stuffs and forage additives (J. Latvietis, L. Kārklā, L. Degola et al.), and seeking ways of solution to the problem of forage protein (J. Latvietis et al.), testing, and comparing feedstuffs processing methods (R. Kristapa, A. Sleze). Much work has been done to introduce new methods to evaluate feedstuffs and to implement standards in nutrition of cows (U. Osītis).

In 1998 the Ministry of Agriculture adopted the new ration setting system for nutrition of highly productive cows based on aforesaid approach. In contrast to the old system which used oat nutritional units, cows' energetic needs and feedstuffs containing energy amount are expressed in a new unit: net energy for lactation NEL. The new system, besides measurement of energy, rationalises fibre fractions – neutral (NDF) and acid (ADF) detergent fibre as well as protein fractions – in rumen degradable and in rumen undegradable or by-pass protein.

The most important task in nutrition of highly productive cows is to achieve higher consumption of food for every cow, consequently to accumulate more energy. It turns out that the amount of feedstuffs – hay, haylage and silage – consumed by a cow can be foreseen by ascertaining the total amount of fibre in these feedstuffs that are called "neutral detergent fiber" (NDF).

The ration setting according to the customary norms for crude protein or digestible protein of ruminant nutrition does not meet physiological peculiarities of these animals.

Any protein or substance containing nitrogen (e.g. soya oilcakes or carbamide) degrade in the ruminant's rumen microorganisms down to ammonium, then it used to produce microbes' protein, i.e., microbes work and they also grow themselves in the rumen. The protein amount produced by microbes is rather constant quantity for a cow; therefore, very important part of protein is that which passes non-degraded through the rumen. Thus, protein rate-setting relates to new notions – degradable and undegradable protein in the rumen.

Theoretical explanation of the new system and possibilities of practical application in setting of cow feed ration can be found in the book "Evaluation of Feed-Subs in Ruminants' Feeding" (1998) by U. Ositis and publication "Summary of Feed-Subs Analyses Results" (2000) by U. Ositis, S. Strikauska, A. Grundmane. Basing on these studies, software "LEDA" was developed to set cows' food rations for all levels of productivity. Both the books and software are available in all Regional Agricultural Advisory Centres throughout Latvia. The Laboratory of Agrochemical Analyses performs forage analyses in compliance with the new norm system requirements.

Currently, the best Latvian herds give 8000, 9000, and 10 000 litres of milk per lactation cow. To ensure stability of the high milk-yield, it is necessary to have further scientific study stage in order to define still smaller protein fractions in feedstuffs consumed by cows. Without these scientific studies it is impossible to set further feed rations with the help of the latest generation software which is meant to ensure milk yield of 9000, 10 000 and more. Therefore, under the guidance of U. Ositis the Laboratory of Agrochemical Analyses approbated the methodology recommended by Cornell University (the USA) to ascertain protein fractions, and compared their results with the results of other leading European laboratories (Uppsala, Prague). Cornell University evaluation system of crude protein partitioned it into three fractions: A, B, and C. Fraction A contains soluble non-protein nitrogen NPN; fraction C has unavailable nitrogen or bound true protein being defined as acid detergent insoluble nitrogen; and fraction B contains true protein and has three subfractions – B₁, B₂, and B₃. Now all the aforesaid fractions are definable by chemical methods in a laboratory. Hitherto, defining was possible only using cows having rumen fistula and it was very expensive.

All the time we have had an extensive cooperation with other agricultural universities in Sweden, Germany, Great Britain, and Denmark.

Basing on the performed studies, scientific and practically significant books and brochures have been written including text books: J. Latvietis "Nutrition of Farm Animals" (1991), "Pig Nutrition Norms" (1994, 1998), "Catalogue of Forage" (1996), "Cows Nutrition Norms and Feedstuffs Requirements" (Ositis, 1995), "Evaluation Systems of Feedstuffs Energy and Protein in Different European Countries" (Ositis, 1996), "Evaluation of Feedstuffs in Ruminant Nutrition" (Ositis, 1998), "Beef Cattle Nutrition" (Ositis, 2000), "Dairy Cows Nutrition" (Ositis, 2002), "Complex View of Animal Nutrition" (Ositis, 2004, 2005), and "Horse Nutrition" (Ositis, 2007).

During the last decade two doctoral theses (L. Degola and A. Trūpa) have been developed and defended in the Department of Animal Nutrition.

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