Latvia University of Agriculture

Proceedings
International Scientific Conference

ACADEMIC AGRICULTURAL SCIENCE IN LATVIA – 150

September 19–21, 2013
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Preface

Proceedings of the Latvia University of Agriculture (LLU) will be received by readers during a large international conference with local and foreign participants. This conference is very special because it is dedicated to the 150 years' anniversary of our university. The beginning of higher agricultural education in Latvia started 150 years ago. One and a half century ago the Agriculture Department was established at the Riga Politechnics. During years it was developed and transformed into an independent higher education institution which obtains a state university status and holds a stable position in the Latvian higher education system.

Our scientists in agriculture, forestry, veterinary, food, economy and other branches of science have done a lot of work in order to investigate and comprehend the deepest events of our history, including the history of science. The documents found in archives and other evidences, as well as studied monographs, listened contemporary memories will help to come up with new cognitions and facts and to increase the encyclopedic edition "Higher Agricultural Education in Latvia" and the proceedings "Agriculture Science in Latvia 1950 – 1990: Seniors' View". All materials will be summarized and incorporated into a new history book of LLU.

Nowadays LLU has become a significant education, science and culture center not only locally in Zemgale region but also nationally. The graduates from our university are demanded specialists and the main developers of intellectual potential at the Latvia's countryside. Our academic personnel in pedagogical and research work is our golden fund, and we are proud that more than 70% from the elected academic personnel has a doctor degree. LLU takes the 3rd place among other Latvian universities regarding the number of defended doctoral theses.

Development of doctoral and master studies is positively influenced by our participation at the Baltic agriculture university cooperation network – BOVA. This cooperation has almost 20 years of history, and it is oriented to a better training of internationally recognized doctoral and master students. Qualified lecturers from a similar Nordic university network – NOVA are attracted for the training on a regular basis. As an example, NOVA international courses on usage of data processing programme "R" in veterinary medicine and life sciences for 40 doctoral students from 18 different countries were organized recently in Jelgava. Our scientists are active participants also in the Nordic Agriculture Scientists Association – they take part in seminars, conferences and organize experience exchange. The Economic Department of this association organized a seminar in Jelgava where local craftsmen and representatives from their professional associations had discussions on establishment of a cooperation network for local food producers, craftsmen and researchers in order to produce new, innovative products. Scientists from the Faculty of Food Technology investigated the chemical composition of gooseberries - processing, packing and maintenance possibilities. They came up with a conclusion that nowadays these nutrient rich berries are cultivated only as a cultivar of small household gardens and have been little used for a broader processing in Latvia and Europe. Chemical composition of 10 cultivars of fresh and frozen gooseberries at different readiness degrees were investigated in order to select the best cultivars for drying and to propose them to interested commercial companies for processing.

Signed cooperation agreement between LLU and the Latvian Science Academy envisages the development of research cooperation in agriculture, life sciences, engineering, social and pedagogical spheres of science. The LLU and Latvian State Forest Research Institute „Silava" cooperation memorandum foresees joint cooperation in project development and implementation, common information exchange on research results, as well as development of joint cooperation communication. We are proud and happy that because of different projects in research sector, new laboratory equipment has been obtained for more than 1 million lats. As an institution we pay more attention to our strategic objective which is to implement higher education process in close connection with research and technology transfer.

The LLU Technology and Knowledge Transfer Center has concluded many contracts with producers on execution of various research activities. Construction of new laboratory block of veterinary medicine has been completed at the LLU research and training farm "Vecauce" which recently celebrated its 90 years' anniversary. This year the research farm "Vecauce" has started the formation of "Latvian Brown" breed of cows' gene pool. One of the worldwide progressive management systems - "Afimilk", has been installed and successfully implemented at the farm. This system allows to control and compare the data of each cow electronically.

By implementing a row of large projects of the European Structural Fund, LLU has developed significant research oriented projects for attracting human resources in field of alternative energy, as well as projects improving material and technical basis for research and study needs. LLU is developing as one of the strongest alternative energy centers in Latvia - extensive research in energy plant growing, production of biogas and its optimization, and solar energy usage are implemented in laboratories and research fields.

The new clinic of the Faculty of Veterinary Medicine started to operate this year. It is one of the most modern and the best equipped clinics in the Baltics, and it is considered to be the reference clinic for treatment of all animal varieties. The experimental and minimal invasive surgery scientific research center has been developed in cooperation with the Riga Stradiņs University. In accordance with the adopted state regulation on Seeds and Cultivars Law, LLU has been delegated the function of evaluating economic qualities of various plant cultivars.

The LLU Lifelong Learning Center has organized international summer schools already for two years. Students of higher level study programmes of landscape architecture and planning from 10 countries acquired variety of landscape and cultural historical values of Latvia and presented their insight on the development of rural territories.

A deeper insight in our scientists' achievements and science development of one of the oldest universities of Latvia you can gain by reading the newest proceedings, and by participating at extensive discussions at the 150 years' anniversary conference. We hope for a continuing cooperation of all types of activities also in the future.

Agriculture Education in Latvia – 150

There is no other as favourable place for ecological agriculture as the territory of Latvia and the Baltic States, considering geographic, climate, biological and all other conditions and being inhabited by the population that is observant, talented, hard working and understands the laws of nature. We occasionally remember this fact, but this year it has been highlighted in Latvia by the 150th anniversary of academic agriculture education and scientific research related to it.

In 1861 Riga as a metropolis of the Baltic States obtained the rights to establish a higher education institution, Riga Polytechnic, to transform the traditional manor and single-family farming agriculture having lasted for centuries to the rapidly increasing pace of European industrial large-scale production. Two years later – in 1863, the Departments of Engineering, Chemistry and Agriculture were formed in it to provide studies according to the industry principle. Since then the practical agriculture education and the academic science have developed hand in hand, promoted by a highly qualified and international groups of scientists and academic staff.

The need for cultivation of the land as the main economic resource in Latvia has secured a continuous development of various branches of agriculture sciences. After the economic concussions brought by the political catastrophe of World War I, the independent state of Latvia was in need of modern national agriculture. Therefore the Faculty of Agriculture within the Latvia University was established in 1919, and then the faculties of Agriculture and Forestry were founded at the Jelgava Academy of Agriculture in 1939. The economic renovation tasks after World War II integrated Latvian agriculture education and science in the system of the Soviet global labour market and economic space with the help of political pressure. The same approach satisfying the needs of industrialized economy promoted the establishment of nine faculties in various specialisation branches at the Latvia Academy of Agriculture since 1944 – the Faculties of Agronomy, Zootechnology, Agriculture Machinery, Veterinary, Forestry, Forestry Machinery, Hydro-amelioration, Land Reclamation, and Food Production Technology providing for further development of academic education and agriculture science.

After the restoration of the independence of Latvia and responding to the need for a flexible approach in new economic conditions the Latvia University of Agriculture – higher education institution in agriculture reorganized in 1991 – has changed along with the integration of the state of Latvia into the market-oriented space of the European Union and beyond according to the criteria set by the cooperation partners. Today the Latvia University of Agriculture as the leading higher education institution of agriculture sciences in the Baltic States provides modern education in eight faculties and 64 internationally acknowledged study programs.

Today, marking the 150th anniversary of agriculture education, the Latvia University of Agriculture, having started as one department at the Riga Polytechnic, has turned into an independent higher education institution uniting unique education and scientific directions. I see the university as a modern economic knowledge centre focusing on the resources of our land and branches related to their utilization. These should be developed for the benefit of regional policy of this country to satisfy economic and spiritual needs of the population striving to include its knowledge, skills and achievements in European as well as higher education and research space in a broader sense.

I greet scientists, professorship, academic staff and students of all branches of academic research on the occasion of the 150th anniversary of agricultural academic education of Latvia. I wish Latvia University of Agriculture to teach to honour the main resource of the national economic sovereignty – the land of Latvia – firmly taking roots in our land and people, to raise self-esteem with its achievements in academic research, improving modern farming skills for the benefit of themselves and our country.

Ojārs Spārītis
President of the Latvian Academy of Science

The Importance of Higher Education in Agriculture at the Riga Polytechnic School/the Polytechnic Institute

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Abstract. Higher education in agriculture in the territory which is now Latvia began in 1863, when the Department of Agriculture was founded at the Riga Polytechnic School, a private institution of higher education. After its reorganization in 1896, it became a state institution and was renamed the Riga Polytechnic Institute, with Russian as the language of education. In the course of time, the duration of studies was prolonged from two to four years. From 1863 to the 1918/19 study year, the Department had 591 alumni, who worked not only in the Baltic provinces but all over Russia, Poland, and the Caucasus. The students of agriculture came from different nationalities, and among them were Latvians who developed the agrarian sciences in different sectors, wrote textbooks and developed agricultural sciences into one of the main branches in Latvia in the first half of the 20th century. This task is now continued at the Latvia University of Agriculture in Jelgava.
Key words: Higher education, agriculture, Riga Polytechnic School/Polytechnic Institute.

Introduction

The privileges of King Sigismund of Poland were given to the Baltic Knights in 1561, after they and the German Order, who defended them, lost the battle with Poland. These privileges were renewed in 1629, when the Swedes defeated the Poles, and after the Great Nordic War in 1710, when the Russian Tsar Peter the Great defeated the Swedes. These privileges not only granted the Baltic Nobles the right to use their German language, to conserve their religious beliefs and to have the right of self-government, but they guarantied also the ownership of their large properties. So they remained the landlords, and they had to live on their agricultural revenues. They needed qualified administrators for their properties who would know how to conduct agriculture. In some cases, the sons of the Barons went to Germany to study agriculture at the Academy in Bonn–Poppelsdorf, or forestry at the Academy in Dresden-Tharandt.

When the institutions of the Town of Riga and the Börsen-Commerz-Kommittee (Committee of Stock-Exchange and Commerce) started to develop the project of the founding of the Polytechnic School, two special interests developed which had to do with the special socio-economic situation of Riga. It was a town that earned its profit from the harbour, and its commerce and the country was dominated by agriculture. So, the institutions and the Committee decided to include these two specialties into the project of the Polytechnic School, where they would not normally be found. The partition of power between the German barons and the Latvian farmhands remained unchanged until the end of the Russian Empire in the Russian Revolution in 1917/1918. The end of the Russian Empire and the end of World War I gave rise to a new and independent Latvian State – the state that was interested in a sound agricultural education, as it had expropriated the Baltic barons and had given it to the many former farm hands. It was their task now to feed themselves and the country.

Earlier, after the abolishment of slavery in the Baltic provinces of Russia in 1861, the first independent Latvian farmers started to work and obtained the rights to buy property. This was the true start of Latvian agriculture. Social structure changed in the villages. A class of agrarian workers and Latvian private owners developed. The high price of the land could only be paid by conducting an intensive agriculture that demanded education in agriculture (Knieriem, Bucholtz, 1915).

Higher education in agriculture in the territory which is now Latvia began in 1863, when the Agricultural Department of the Polytechnic School in Riga began to work. The Department continued its task at the Polytechnic Institute until 1918. In 1919, the Riga Polytechnic Institute was closed down, and, in the same premises, the institution of higher education of Latvia was founded, in which the Department of Agriculture was incorporated and became the Faculty of Agriculture. Later, in 1922, the institution was renamed the University of Latvia.

In 1939, the Faculty of Agriculture of the University of Latvia became an independent institution of higher education – the Academy of Agriculture in Jelgava (today – Latvia University of Agriculture). Agriculture and the education in agriculture play an important role in the national economy of Latvia, they represent a long tradition of the relation of the country and its people to agriculture. The proverb says, 'Latvians are farmers'. The institution of higher education of agriculture celebrates its 150th anniversary in 2013.

Material and methods

To get an overview of the development of higher education of agriculture, documents of the Agricultural Department of the Polytechnic School and the Polytechnic Institute of Riga were studied and analyzed. Previous works about the history of the Department of Agriculture were written by the professors Woldemar von Knieriem, Feodor Buchholz, Gustav von Kieseritzky, Jānis Stradiņš, and others. For the preparation of this article, the documents, books and articles from archives, libraries, and the Museum of Riga Technical University were used. The original documents were analysed using the hermeneutic method, and for statistics the qualitative data analysis was applied.

Results and discussion

Though higher education in what is now the territory of Latvia begins with the foundation of the Riga Polytechnic School in 1862, the Department of Agriculture calls 1863 the year of its foundation, because that year the first students were enrolled. The young students of engineering sciences with insufficient knowledge in natural sciences and mathematics had to enrol in a preparatory course that was offered in Riga, and they started their studies after having finished this course. This also applied to the students in agriculture. Thus, the Department of Agriculture started the study year 1863/64 with four students. Because of their small number, there were no professors and no courses in agrarian subjects, but some good basic courses were available in such natural sciences as botany, mathematics, physics, and zoology.

In the next year of studies, 1864/65, the students learned chemistry, mineralogy, geology, agrarian machinery, construction, and book keeping. In 1864, the professor of chemistry August Toepler came to Riga to teach chemistry; he also established a chemical and agrarian experimental station. Prof. A. Toepler had been working at the Agricultural Academy in Bonn-Poppelsdorf and had five years of experience.

In the 1864/65 study year, the number of students in agrarian sciences increased to eight and, since studies at that time were set to two years, the first diploma in agriculture was granted already in 1865. The first alumnus (1865) was Wilhelm von Bergmann, and the next alumni (1866) were Leon Kulbach and Adolf Doss, both from Livonia. In 1867, Mieczyslaw von Sadovsky from Kaunas received his diploma (Siebenter..., 1868).

Only in 1868, Karl Hehn (1821–1875), who was the first professor of agrarian sciences at the Riga Polytechnic School, arrived in Riga from Dorpat/Tartu University. He reorganized the study program in agrarian sciences and introduced typical agrarian courses into the program: arable farming, meadow farming, plant growing, gardening, forestry, animal production, and agrarian economy. K. Henn was appointed the first dean of the Department. It should be mentioned that the position of a dean was established only in 1869. The duration of studies increased to three years.

In 1873, when K. Hehn was offered the position of professor at the University of Dorpat/Tartu, Jegor von Sievers (1823–1879) was called on his chair, and he continued reorganization of the Agricultural Department. In his time, a station for the control of seeds was founded; in 1877, the experimental station "Peterhof" (Peters' farm) was founded in Olaine (Ozols, 2002). This was very important for the practical scientific courses of students and their teachers.

To integrate theoretical and practical aspects, an intensively used farm near Sassenhof/Zasulauks of the co-founder of the Riga Polytechnic School Adolf Thilo was used as a study and research base (Knieriem, Bucholtz, 1915). Excursions were organized to show the production of agrarian machinery in Riga, the large agrarian enterprises of the town of Riga, as well as forests, meadows, and gardening; besides, experiments about soil quality were carried out (Fünfzehnter, 1876).

In 1875, professor von Sievers started another reorganization of the study program by introducing new subjects, such as botany, zoology, geography of plants and animals, climatology, knowledge of the weather and its phenomena, quality of soil, health of animals, and chemistry of animals. Also optional subjects were introduced – diseases of plants, entozoa of domestic animals, knowledge about wool, dairy farming, help at animal birth, cultivation of tobacco and hop, construction of agrarian ways and waterways, etc. In order to put it into practice, correspondingly qualified teachers were needed. In 1867, private docent Reinhold Wolff arrived in Riga from the University of Halle, Germany.

The Department of Agriculture had frequent contacts with associations of agriculture and gardening.

After the death of Jegor von Sievers, the Department of Agriculture was lucky to win over the scientist Woldemar von Knieriem (1849–1935) from the University of Dorpat in 1880. In the same year, he became professor and directed the agrarian experimental station in Peterhof. Later, in 1903–1906, W. von Knierim was appointed the dean of the Department of Agriculture, and in 1906–1916 – the director of the Riga Polytechnic Institute. As director of the experimental station he strongly stressed the need for practical experience. He held the opinion that the way how agricultural education is organized in the Baltic provinces is of eminent importance for the life of each nation, its culture, and economy. The conditions of nature in the Baltic provinces favour the development of agrarian production, which should lead to its further concentration in these countries (Knieriem, 1912).

Since 1882, students passed their last semester in Peterhof accomplishing their practical and theoretical tasks there. One of the professors lived in Peterhof, and for students there was a students' home. They learned to live as farmers – worked on the field and took care of farm animals. Since

1883, students heard their final agronomic lectures in Peterhof. Peterhof gave a possibility for the development of a collegial and even familiar atmosphere between professors and students, who quite often sat around the same table.

In 1885, professor Wolff left the Department of Agriculture, and his chair was taken over by Heinrich Freiherr von Bretfeld from Saxony, Germany. His presence at the Department was very short – H. F. von Bretfeld died in 1888, and his position was taken over by Franz Schindler, private docent of the University of Agriculture of Vienna. In his research, Bretfeld laid more stress on the method of microscopy, knowledge of seeds, and plant cultivation, whereas Schindler's interest was the physiology of plants. At that time, there already existed some textbooks and journals of agronomy, as well as scientific publications in the field of agriculture, forestry, botany, zoology, silk worm breeding, beekeeping, fish farming, etc. (Katalog..., 1895). The library grew in numbers and importance by books which were bought or given as gifts.

In October 1887, when the Polytechnic Institute celebrated its 25 years jubilee, the Department of Agriculture had already developed into a thriving and well-organized institution with 70 alumni and more than 100 students – in the study year 1887/1888, there were 139 students (Siebenundzwanzigster..., 1888).

In 1896, the Riga Polytechnic School was reorganized and was renamed the Riga Polytechnic Institute. It became a state institution with Russian as the language of education. It was possible to finish the studies under the old regulations until 1901. The studies that had lasted for three years were prolonged to four years, and consequently the study programs were revised and improved from time to time (Программы..., 1903). The foreign professors who could not deliver their courses in the Russian language left the Riga Polytechnic Institute.

In 1903, professor Schindler was offered to work as a professor at the University in Brünn. Professor Thoms died. The docent of forestry sciences Eugen Ostwald was replaced by Bronislaw Poncet de Sandon, alumnus of the Academy of Forestry in St. Petersburg.

Since the end of the 19th century, the Polytechnic School alumni started to teach as teachers at the institutions of higher education. Martin Stahl-Schröder, Percival Friedrich Stegmann, Stephan Basarewski, the alumnus of the Polytechnic Institute in Riga Arnold Buschmann, and others worked as assistants and, later in the 20th century, as professors (Album..., 1912). In 1897, the alumnus of the University of Moscow Fjodor Buchholtz came to Riga and later became the dean of the Department of Agriculture (1912–1918).

Since 1898, the Department of Agriculture had its own forest wardens office, and in 1906 the Department was allotted an approximately 1300 ha large forest area (Vasiļevskis, 2001).

In Peterhof, in1912, a one-year course in cultivation of peat bogs was opened for the alumni of the Polytechnic Institute in Riga and of other institutions of higher education in Russia. For this purpose, the Institute received another plot of 173 Desjatinen (approx. 188 ha) (*Festschrift*..., 1912).

Before World War I, the Department of Agriculture had the leading position in the education of agriculture in Russia. As the German troops progressed fast, all the Polytechnic Institute was evacuated to the interior of Russia in the summer 1915. Before leaving, the Russian army set the fire to the facilities of Peterhof and 2000 books in the library, all the documentation for the diplomas of alumni and most part of the equipment of the Department burned down (Knieriem, 1935). So, not all of the plans were realized. It had been intended to split the Department into two departments: department of agriculture, and department of forestry.

After evacuation to Moscow, the Department of Agriculture of the Riga Polytechnic Institute worked in the buildings of the Department of Agriculture of the University of Moscow and the docents from Riga became the docents of the Moscow University. Woldemar von Knieriem, the former professor and dean of the Department of Agriculture (1903–1906) and former director of the Polytechnic School, was dismissed as he had accepted the enrolment of the young men as students who otherways would have to go to the army instead.

The academic staff of the Riga Polytechnic Institute could not continue their tasks in Moscow. In 1918, because of the Russian Revolution, the activity of the Polytechnic Institute was interrupted. In the meantime, Latvia had declared its independence, and, under the German rule, the Baltic Technical University in Riga with German as the language of instruction continued its work. In 1919, a decision was taken to found an institution of higher education in Latvia. In August 1919, the Polytechnic Institute was closed down. Its tasks were continued in the new institution of higher education of Latvia, which later, in 1922, was renamed the University of Latvia.

The science of agriculture

The Department of Agriculture researched different aspects of agriculture. K. Hehn laid the foundations of the Baltic Agrarian Statistics; Woldemar von Knieriem worked in the sector of milk production as well as researched intensive use of the soil; and the agro-chemist G. Thoms was known for his analysis of peat and for his research on the quality of soil in the Baltics. Under the supervision of the Russian Ministry of Agriculture, the scientists at Peterhof studied optimization of fertilizer use and developed new plants as well as new techniques for feeding cows. In the experimental station, seeds and different sorts of food were analyzed and methods were developed to improve the situation. The experimental station took part in agrarian expositions, and its staff participated in scientific congresses. The results of the research of the well-known agro-chemist Justus von Liebig and of the chemist Adolf Meyer were put into practice because agriculture is strongly tied to chemistry, which was demonstrated both in their courses and practical work. Students went to study abroad; however, because of the differences in soil and climate, not everything could be applied in Latvia.

The scientists published their research results in public press, scientific journals, and books. In 1914, the Department of Agriculture was the first of the departments of the Riga Polytechnic Institute to publish scientific works. Three fascicles were published (1914–1917); each of the books was composed of four cahiers, each of which had a common and a special part (Извѣстія...1914–1917). In the common part we find reports and the chronology and titles of the written diplomas; in the special part, there are scientific works of the professors and students.

Alumni

In the time period from 1865 to 1919, a total of 591 students graduated from the Department of Agriculture (Rīgas..., 1938) – only men, because women were enrolled at the Riga Polytechnic Institute only from 1917 on – and other students later finished their studies at other universities and among others at the University of Latvia. Approximately 1/3 of those who started the studies finished them. The number of those who were enrolled and of those who finished is shown in Table 1.

The first students were Baltic Germans from the provinces, but at the end of the 19th and at the beginning of the 20th century students came from all over Russia and also from Poland. Among the students, the number of Latvians grew steadily. After having finished the studies, only ¼ of the

Table 1

The number of students and alumni (1863–1919)

Year of studies	Number of students	Number of alumni	Year of studies	Number of students	Number of alumni
1863/64	4	-	1891/92	109	6
1864/65	8	1	1892/93	140	6
1865/66	8	2	1893/94	133	8
1866/67	6	1	1894/95	143	13
1867/68	4	-	1895/96	157	10
1868/69	6	1	1896/97	178	14
1869/70	6	1	1897/98	191	16
1870/71	16	-	1898/99	180	18
1871/72	19	1	1899/00	184	11
1872/73	14	2	1900/01	182	40
1873/74	9	1	1901/02	146	20
1874/75	14	-	1902/03	132	29
1875/76	24	1	1903/04	121	22
1876/77	34	4	1904/05	143	8
1877/78	51	5	1905/06	134	14
1878/79	56	5	1906/07	89	10
1879/80	49	-	1907/08	117	17
1880/81	55	4	1908/09	144	13
1881/82	48	8	1909/10	175	9
1882/83	69	8	1910/11	226	15
1883/84	88	10	1911/12	274	8
1884/85	91	8	1912/13	299	19
1885/86	96	4	1913/14	378	34
1886/87	115	3	1914/15	357	33
1887/88	122	15	1915/16	382	17
1888/89	118	18	1916/17	207	22
1889/90	96	13	1917/18	?	20
1890/91	93	18	1918/19	?	5
			Total		**591**

students remained in the Baltic provinces. More agrarian specialists were needed, and popularity of the Polytechnic School was high, everybody could study there. When it was launched, it was a private institution of higher education, students had to pay fees (at the start, the fee was 120 Rubles; later, in the 1890s, it was 150 Rubles), and access was open to all students regardless of religion, nationality, or social status. The first alumni got the diploma of a farmer, later – the diploma of an

Table 2

Alumni of the Department of Agriculture of the Riga Polytechnic School/Polytechnic Institute (1865–1919) with a doctor's degree

No.	Family-name, Christian-name, date of birth and death	Year of Diploma	Doctor's degree and University
1.	Basarewski Stefan (1871–1943?)	1895	1906, Dr. phil., Göttingen
2.	Bondarzew Apollinary (1877–1968)	1903	1934, Dr. biol.
3.	Eglītis Maksis (1892–1974)	1918	1932, Dr. sc. nat., ETH Zürich 1935, Dr. agr., Latvia
4.	Ertzdorff-Kupffer Nikolai Harry (1890–?)	1912	1915, Dr. (ing.?), Munich
5.	Galenieks Pauls (1891–1962)	1918	1936, Dr. rer. nat., Latvia
6.	Chrebtov Aristoklij (1876–1944)	1908	1937, Dr. agr.
7.	Lejiņš Paulis (1883–1959)	1907	1945, Doctor of agr.sc.
8.	Lemus Woldemar (Vladimir) (1871–1938)	1899	1901, Dr. phil., Leipzig
9.	Pickardt Edgar (1876–1973)	1899	1902, Dr. phil., Leipzig
10.	Pissarew Boris (1875–1908)	1898	1899, Dr. phil., Jena
11.	Ruschmann Karl (1864–?)	1896	1897, Dr. phil., Leipzig
12.	Strasdowski Eduard (1863–after 1940)	1891	1893, Dr. chem., Jena
13.	Stahl-Schröder Martin (1862–1911)	1888	1891, Dr. phil., Leipzig; 1903, Dr. agr., Kiev
14.	Stegmann Friedrich Percival (1868–1938)	1895	1905, Dr. phil., Jena
15.	Schultz Eduard (1876–1911)	1901	1905, Dr. phil., Munic
16.	Tamamschew Alexander (1877–1967)	1903	1937, Dr. agr. (Yerevan?)
17.	Vārsbergs Jānis (1879–1961)	1908	1932, Dr. agr., Latvia

agronomist, and the best students received the attestation of good results. After the reorganization in 1896, the alumni with good marks were granted the first-grade diploma, the others – second-grade diploma (Положение..., 1896). Since 1904, everybody obtained the diploma of an experienced, "Erudite", Agronomist.

At least 17 alumni were conferred the Doctor's degree (Table 2), which made almost 3% of all the alumni of the Department of Agriculture; besides, two of them earned two doctoral degrees. Three alumni (Paulis Lejiņš, Jānis Mazvērsītis, and Juozas Tūbelis) were awarded the honorary degree *honoris causa*.

The alumni of the Department of Agriculture occupied different professions. They worked at different institutions of higher education – at the University of Latvia (Jānis Bergs, Jānis Bickis, Pauls Galenieks, Paulis Lejiņš, Maksis Eglītis, Jānis Vārsbergs et al.), at the Academy of Agriculture in Jelgava (from 1939), at the Dairy Farming Institute in Wologda in Russia (Aristoklij Chrebtov), and at the University and the Institute of Higher Education for Zoo-veterinarians in

Yerevan/Armenia (Alexander Tamamschew). More than 10% of the alumni worked as teachers at professional schools to educate the farmers. The alumnus Vilis Gulbis became the Minister of Education of Latvia; Juozas Tubelis – the Minister of Education, of Finance, and of Agriculture in Lithuania; Paulis Lejiņš became the first president of the Academy of Sciences in Latvia. Also foreign students who had studied at the Department held high posts in their homelands. So the mycologist and phytopathologue Apollinary Bondarzew became a scientist who was well-known not only in the Soviet Union but also in other foreign countries. The alumnus Jānis Bisenieks founded an agrarian school and the Latvian Agrarian and Economic Society in Jelgava. He edited a calendar for peasants which propagated practical advice.

The importance of the Department of Agriculture

The alumni later worked in different countries, some even did not return to their homeland, but all were specialists in agriculture and worked to improve agricultural production. The estates of the Baltic nobles developed into modern and productive entities, but ¾ of the alumni worked outside the Baltic provinces (Stradiņš, 1999).

One part of the alumni worked in Livonia and Courland that now are a part of Latvia, and the knowledge obtained during studies was used to produce traditional products such as wheat, fruit, vegetables, fodder, livestock, and wood. A new branch was the cultivation of sugar beet, which developed well in Poland and also in different parts of Russia.

It was characteristic for the Polytechnic School/the Polytechnic Institute that a highly professional educational system was linked to research and there was a very strong cooperation between the education at the institute of higher education and the local industry and agriculture (Stradiņš, 1999). At the Department of Agriculture, Latvian scientists and economic and social co-operators have obtained their education in agriculture. The teachers of the Faculty of Agriculture of the University of Latvia came from the Riga Polytechnic School/Polytechnic Institute and one part of them – from the Academy of Agriculture in Jelgava, which was founded in 1939. The experience of the Department of Agriculture and its students was implemented into practice in many institutions of higher education where agriculture was taught. The educational and experimental Station “Peterhof” has influenced the science of agriculture not only in the Baltic provinces but also in all Russia and was a good example for a good and economic production of crops and livestock. From “Peterhof”, the knowledge was brought out to professional schools of agriculture and to different institutes and associations (Augstākās..., 2002).

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From the Past until Today 150th Anniversary of Agricultural Education in Latvia

Antons Ruža

Till the beginning of the 19th century, agriculture developed comparatively slowly – with small differences between countries and lands. Crop yields were low: 5 to 10 quintals per ha. The main crops grown in large areas were cereals, mainly wheat, barley, and rye. In the Northeast of Europe – Poland, Russia, and the Baltic countries –, rye was the main cereal species and the most important food product.

Significant changes in the development of agriculture began at the end of the 17th and in the 18th century and were associated with the great geographical discoveries, in the result of which new crops, including fodder plants, were introduced. This increased the forage base, thus allowing to keep more livestock and to produce more manure for soil fertilisation. During this time period, agricultural science began to develop quite rapidly, particularly studies in soil, plant nutrition, plant fertilization, tillage, crop rotation, and weed infestation. Achievements of the Western agricultural science and practice were relatively quickly introduced in the Baltic German manors in the territory of Latvia.

During the initial phase, from the mid-17th century to the last quarter of the 18th century, all the books on agriculture in Latvia were published in German, as they were intended for the needs of the Baltic German nobility. Thus, at the beginning of the 17th century, Zachary Stopius, a physician living in Rīga, wrote a book in German – "Economy in Vidzeme" (1645). This work is considered the first overview of the agricultural knowledge, the first Latvian agricultural manual. The book had four editions, and, in 1747, M. Lomonosov translated it into Russian. In 1753, F. Fisher's book "Vidzeme Agricultural Yearbook" was published, and it was translated into Russian by V. Livshin in 1772. These works discussed practical problems of agriculture and offered observations of ancient Roman writers.

First agricultural books translated into Latvian appeared only at the end of the 18th century. The work by C. Gercimsky "Land and House Care for Latvian Youth" was published in Jelgava in 1783, and it discussed issues related to cultivation and partially also to fertilisation. In 1789, the book by J. Shubart von Klefeld "Advice Given to All the Ploughmen who Lack Food for the Animals" was published in Jelgava. It covered forage preparation issues and possibilities for growing clover in Latvia.

In 1790, the book by F. Vars "Potato Field" was published in Rīga. The author encouraged the readers to grow potatoes and provided his advice in agriculture technologies. In 1803, two books in Latvian were published: one by J.H. Zigra in Rīga – on gardening; another by Kr.V. Launics in Jelgava – on beekeeping. During this period, also agricultural yearbooks were published.

Publications in Latvian were intended for Latvian peasants. However, the heavy corvee in manors in the countryside discouraged the peasants from using these tips and instructions, and the publications did not get response from the farmers. Not understanding the reasons, the advocates of the agricultural ideas reproached the peasants for holding to their fathers' farming techniques and soon ceased to work in the farming sector. Thus, in the following years, agricultural literature again was published only in German, promoting adjustment of foreign agricultural ideas to the

local situation. Only in the 30s–50s of the 19th century, when the corvee system and soil cultivation capabilities had changed, the whole agricultural farming changed as well. This book dealt with different methods of land cultivation depending on peculiarities and characteristics of soil and crops and covered fertilisation and other issues.

K. Lepevics had an important role in forming the agronomic views in Latvia. His book "Counselor for Farmers", published in 1852, was a significant event in the farmers' community – it employed a scientific approach to explain many issues basing on the advances in biological sciences.

The opinions expressed by G. Braze and K. Lepevics later served as the basis for developing agronomic science in Latvia.

As farmers started buying houses next to the gentry farms, independent Latvian farms began to form. In order to spread the latest and the most rational ideas about tilling, crop fertilisation, crop rotation and other management practices among Latvian farmers, agricultural societies were established and farmers' meetings were held. A great role in this work was played by the first Latvian agronomist with special higher education Rihards Tompsons (1834–1884).

Extensive contacts of the Baltic nobility with Western Europe, promotion and distribution of scientific research and knowledge, as well as changes in the public relations of Latvian countryside contributed to the need for knowledgeable and educated country estate executives and managers.

In 1862, the Rīga Polytechnicum was established, and, already a year later, in 1863, the Agricultural Department was created there. Thus, higher agricultural education was launched in Latvia. Originally, the Rīga Polytechnicum was a private university that was subsidised by the Baltic nobility and the city's stock exchange.

The Agricultural Department of the Rīga Polytechnicum was closely related to the development of agriculture not only in the Baltic States but also in the whole Russian Empire, which at that time included also Poland. Together with the University of Tartu, the Rīga Polytechnicum was a link between Russia and Western Europe, carrying the progressive Western ideas and innovations through the Baltic States to Russia.

In the 1863/64 academic year, students of the Agricultural Department of the Rīga Polytechnicum learned general, mostly theoretical, disciplines, such as mathematics, physics, chemistry, botany, zoology, geology, as well as disciplines directly related to the specialty – agricultural machinery, construction, and accounting. In 1865, an agricultural and chemical experimental station was established; practically it was an expanded laboratory for analyses and inspection. The task of the station was to control the quality of imported fertilisers in the Latvian ports and in the port of Pärnu, as well as to provide control of the composition of different materials used in agriculture and other sectors. In 1874, in different places of Latvia (Pierīga, Olaine, Kuldīga district), field trials were launched to explain the different influence of fertilisers, bone meal, guano, and manure on the yield of crops.

Sector-specific subjects – farming, cultivation, grassland management, horticulture, livestock farming, management and administration of estates, agrochemistry, soil science, agricultural history and statistics, use of livestock farming products, as well as forestry – were included in the curriculum of the Agricultural Department in 1868.

Significant changes in agricultural studies began in 1877, when a study and research farm was established in Pētermuiža (Peterhof) in Cēsu district. From 1880, Voldemārs fon Knīrīms was in charge of practical training of students. It should be noted that he was the grandfather of the future

Prime Minister of Sweden Olof Palme (1927–1986). Now, in his former farm Skangaļi, there is Salvation Army's children education centre supported by the Swedish government.

At this time, after the year 1874, research activities also expanded, particularly in agrochemistry and soil science (prof. Georgs Tomss). Merits of two professors – V. fon Knīrīms and G. Tomss – in creation of the Agricultural Department cannot be overestimated.

New perspectives in studies and scientific work opened in 1896, when Rīga Polytechnicum was transformed into a public educational institution – Rīga Polytechnical Institute. German language was replaced with Russian, and material basis of the Institute was improved.

Since 1904, the official qualification "qualified agronomist" was granted to the graduates. During their studies, future professionals gained comprehensive knowledge in key agricultural sectors (except gardening and vegetable production, which were not included in the curriculum), as well as practical skills to manage manor farms with a number of manufacturing industries typical of the Baltic provinces. The study plan of the Agricultural Department did not include the humanities, as it was believed that this knowledge should be acquired in general education establishments.

The highest development of the Agricultural Department was reached shortly before the World War I, when the chemistry course was given by professor Pauls Valdens (Walden); arable farming and agricultural economy – by professor V. fon Knīrīms; general livestock farming – by associate professor Persival Stegma; specific livestock farming and dairying – by associate professor Arnolds Bušmanis; forestry – by associate professor Bronislaw Ponset de Sandon; specific crop production – by assistant professor Wilhelm Bursians; veterinary medicine – by assistant professor Karl Kangro; and botany and plant physiology – by professor Fyodor Buholc. Starting from 1912, under the authority of the Department, the first advanced study courses in swamp cultivation and grassland management in the Russian Empire were launched in Jaunpētermuiža (from 1921 – Pēternieki) swamp culture experimental station. In Pētermuiža and in the surrounding estates, trials on the efficiency of the use of fertilisers, on the suitability of new crops for production, and on livestock feeding techniques were carried out by the teaching staff. Besides, they also published articles on rational management of estates in the Baltic German press.

During the World War I, when the front approached in July 1915, the Rīga Polytechnical Institute was evacuated to Moscow, but the study and research farm "Pētermuiža" ("Peterhof") was destroyed during the hostilities.

In 1919, after the World War I, the Higher School of Latvia was established in Rīga. Later, on 25 March 1923, when the Constitution came into force, it was officially named the University of Latvia. To meet the study and research needs of the Faculty of Agriculture, two farms were established: "Rāmava" and "Vecauce".

The Faculty of Agriculture belonged to the University of Latvia until 1939. On 23 December 1938, the State and Prime Minister Kārlis Ulmanis declared the law on "Constitution of Jelgava Academy of Agriculture". From this date, the Faculty of Agriculture is related to the Jelgava Palace.

Research in Crop Production

Aleksandrs Adamovičs

The origins of the science of crop production and grassland management in Latvia reach back to 1912, when courses on swamp cultivation were taught at Rīga Polytechnical Institute

and when a swamp culture experimental station was established in Jaunpētermuiža (from 1921 – renamed Pēternieki).

The intensive work at the swamp culture experimental station was supervised by Pēteris Konrāds (director in 1921–1945). The research was focused on peatland drainage types and intensity, pre-crops and cover crops of grassland, mixes of pastures and meadows, fertilisation and liming. P. Konrāds also studied the formation of plant groupings in sown lawns and in Lielupe meadows.

A permanent testing field in the Experimental farm (later – Research and Study farm) "Vecauce" was arranged after the World War I (1921) under the supervision of its director Jānis Bergs. A great help and the manager of practical work during this time was Pauls Dermanis.

In "Vecauce", experiments in testing of different types of grassland fertilisation, liming and cultivation were organised. In the 1930s, a wider range research in grassland management were managed and conducted by Jānis Vārsbergs.

In 1937, Jānis Lucāns took active part in the "Vecauce" experimental work carried out by the Department of Crop Production. His experience gained during the internship at Swalef Breeding and Experimental Station in Sweden was very valuable. J. Lucāns developed his doctoral thesis for acquisition of the doctoral degree in agriculture, and defended it in 1943.

In the "Vecauce" experimental field, Latvian traditional crops, as well as less known species and varieties were tested. A relatively large collection of annual and perennial plants was cultivated and observed. More thorough studies were carried out in the fields of national importance.

Maize (*Zea mays*) was extensively studied in Vecauce under supervision of J. Lucāns. Suitability of varieties and hybrids to the Latvian conditions has been established by precise research, as well as crop density, sowing types and rates, field germination, corn-cob formation, chemical composition, nutrient accumulation process, harvest time, and other issues have been studied.

From autumn 1957, Jānis Lauva managed the experimental field for the next 10 years. Under his supervision, extensive research on sugar beets (*Beta vulgaris saccharifera*) and caraway (*Carum carvi*) was conducted.

Analysis of the winter and spring vernalisation issues was led by Antonijs Valainis in the study and research farms of Vecauce, Rāmava, and later also in Jelgava. A. Valainis succeeded in obtaining spring wheat (*Triticum aestivum*) (also in large amounts) from different winter wheat varieties suitable for creating new varieties. His doctoral thesis was only the beginning of a series of experiments, which A. Valainis continued throughout his entire working life.

Pauls Freimanis studied kok-saghyz (*Taraxacum kok-saghyz*), Marianna Ozoliņa focused on soya (*Glycine max*), and Imants Holms – on field beans (*Vicia faba*). Their research results were presented in their doctoral theses.

In "Vecauce" and other farms, Viktors Tērauds carried out a wide-ranging research of grassland, particularly natural meadows and pastures, the results of which were summarised in his doctoral thesis, which was the first post-war thesis on grasslands. He developed a pasture productivity trend scale, which is still used in forage production estimates. Continuing methodically sound trials in arrangement, fertilisation and use of pastures and meadows, V. Tērauds collected a rich material for the book "Meadows and Pastures", which later had three editions. In practical grassland management, V. Tērauds research on the extension of optimal harvesting time of hay by seeding a number of grass mixtures with a different growth rate is highly valued; his method allowed obtaining 30% more crude protein compared to seeding only one grass mixture. This principle is now widely used also in formation of cultivated pastures.

V. Tērauds was an outstanding teacher and much beloved scientific advisor among the students. Under his leadership, two of his students elaborated their doctoral theses in Vecauce: Valdis Tiltiņš – "Effect of grass mixtures on productivity of pastures arranged in drained lowland bogs and on the beginning of the pasture" in 1967, and Alberts Vucāns – "Studies on the watering of cultivated pastures arranged in drained mineral soils in the southwestern part of the Latvian SSR" in 1970.

In Vecauce, Valentīna Ancāne elaborated her doctoral thesis on fenugreek (*Trigonella coerulla*); manager of the experimental field J. Lauva – on fodder roots; and Venta Smagare – on comfrey (*Symphytum asperum*).

In the middle of the 1960s, the research work was gradually transferred from "Vecauce" to the Research and Study farm "Jelgava". Further search for the experimental field sites were related to Pēterlauki and Lapukrogs. There, the land for permanent use was assigned to the LLU a few years later. The year 1966 is considered to be the year of the foundation of the experimental field in Pēterlauki; the first field manager was agronomist Aina Laura.

In the experimental fields of the Department of Crop Production, Imants Holms together with his assistants carried out researches on protein-rich crops: field beans, lucerne (*Medicago* spp.), clover (*Trifolium* spp.), and legume–cereal mixturs. They studied density, germination, cover crops, crop formation characteristics, and quality of these plants. In 1967, I. Holms defended his doctoral thesis on crop management of field beans. His scientific work was comprehensive and well targeted. The main focus of I. Holms' research was cultivation of protein-rich field crops, which was successfully continued by his doctoral student Jānis Driķis, who was the first in Latvia to explore an entirely new protein-rich crop – fodder galega (*Galega orientalis*).

In Pēterlauki, Jānis Lauva conducted extensive research on sugar beets and fodder root crops, oilseed rape (*Brassica napus* ssp. *oleifera*), turnip rape (*Brassica rapa*), and perennial plants recommended for silage. He created non-flowing caraway variety 'Kamarde' and maintained a sample crop collection.

Under the supervision of Laimonis Jurševskis, field trials were organised to study local fertilisation of cereals; combining of technological operations in crop management of cereals; sowing characteristics; field germination; and implementation of technological tracks in the intensive cereal cultivation. A particularly extensive research on the regularities of the formation of cereal productivity (especially physiological aspects of cereal productivity) depending on various agro-technical factors was carried out by his postgraduate students Antons Ruža and Aleksandrs Adamovičs. A. Ruža defended his doctoral thesis basing on field experiments on spring barley (*Hordeum vulgare*) (in 1975), but A. Adamovičs' doctoral thesis was devoted to photosynthetic activity of winter wheat (*T. aestivum*) and to the use of the latest agrochemicals (1968–1976).

In order to obtain high yields and high-quality products from cereals and other crops, the Department of Crop Production paid much attention to intensive cultivation technologies. Many experiments were supervised by J. Lauva, A. Ruža, J. Driķis, A. Adamovičs, as well as by Irma Domniece and Dzintra Kreita.

In 1976–1986, a complex research was carried out on the formation of agrophytocenosis by investigating the effect of nitrogen fertilisers, retardants, desiccants, fungicides, and other substances on the yield – its quality, economic efficiency, and other parameters. At the same time, extensive research continued on the cultivation of protein-rich crops. In collaboration with Beer Barley

Laboratory of the Latvia University of Agriculture, A. Adamovičs conducted complex studies for beer barley production and use.

In Pēterlauki, in 1987, former Head of the Breeding Department of State Stende Breeding and Experimental Station Dr. biol. Ina Belicka started her research on developing new winter wheat varieties; she taught the new breeders as well. Under I. Belicka's supervision, researchers of the Department of Crop Production created new winter wheat variety – 'Moda' ('Otto'), spring barley 'Klinta', as well as generated the breeding material for future crop varieties. I. Belicka was the scientific advisor for several students who elaborated, and later successfully defended, their Master and Doctoral theses in Agricultural Sciences.

After the year 1990, when Latvia became an independent state, the teaching staff of the Department of Crop Production actively participated in the development of the new regulations of crop production. The staff of the Department elaborated regulations for the seed production system, and the normative and methodological standards of seed quality. A. Ruža with his co-workers (J. Lauva, A. Adamovičs, Valērija Ruža) developed 38 seed and grain quality normative and methodological standards, and participated in the development of several draft laws and regulations of the Cabinet of Ministers (Plant Protection Law, Seed Circulation Law, etc.), which were adopted, put into practice and gradually improved in the following years in line with the EU regulations.

In the area of cereal research, the main focus was laid on the quality indicator package, which had not been adequately researched in Latvia before. At the same time, new intensive or very intensive cereal varieties with their own specific requirements were, and still are, introduced in the Latvian countryside; soil cultivation equipment and technologies, as well as fertilisers and plant protection products were changing.

Under supervision of A. Ruža, extensive field trials with different cereal species, mainly winter and spring wheat and barley, were organised. The following topics were explained with the help of research: ability to influence the yield quality (mostly gluten content and quality, falling number and other indicators) under different weather and soil conditions, mostly depending on nitrogen fertiliser.

In the European Union and other Western countries, the main criterion of food wheat quality is the protein content and the Zeleny index or sedimentation value (SV) as the protein quality indicator. Gluten content and gluten quality are used only as supplementary indexes. Unfortunately, practically no studies related to these quality indicators were carried out before 1997. By the order of the Ministry of Agriculture, the first significant researches on the SV were made at the Department of Crop Production in 1998. Their aim was to explain the following issues: the impact of different soil and weather conditions on winter and spring wheat yield and on the formation of its quality indices; the interaction between separate quality indicators and their most important affecting factors; genotypic stability of species; and potential amplitude fluctuations in changing weather conditions and in different growing environments. The research was coordinated between the Latvian scientific and research institutions, enabling a more efficient use of material and technical resources, and, most importantly, obtaining comparable data from different regions of Latvia. The results were disseminated (in scientific articles, in conferences, and on the field in different farms) to cereal producers, which promoted Latvia's becoming a serious exporting country of high quality food grain.

In order to revise the maximum norms of fertilisers (especially nitrogen) for field crops to obtain economically viable yields without polluting the environment, under the supervision of A. Ruža applying a common methodology in geographically different places in Latvia, which differ by the

soil type and climatic conditions (Research and Study Farms "Pēterlauki" and "Vecauce", Priekuļi Field Crops Breeding Institute, and Stende Cereals Breeding Institute), and taking into account the dominance of each crop in a given region, field and laboratory studies were carried out to determine maximum economically feasible and environmentally sound mineral fertiliser standards and nutrient ratios for the respective crops in different regions. The researches led to the development of regulations for fertiliser use; also the theoretical grounds for maximum level of nitrogen fertilisers used in Latvia were submitted to the European Commission.

In order to maintain and improve soil fertility as the national value, it is necessary to explore the processes taking place in soil and plants when applying different field crop cultivation technologies and crop rotations, their benefits and disadvantages, as well as impact on the conservation of sustainable soil fertility. For this purpose, under the supervision of A. Ruža in the Research and Study Farm "Pēterlauki" in Poķi, a specially arranged stationary field plant base was established, where the impact of traditional and reduced soil cultivation on long-term soil fertility preservation, on changes in agro-chemical and agro-physical soil properties, on pest development and distribution, as well as on yield and its quality in no-till crop rotations and in crop rotations with different-density dominant crops was studied.

In 1990, A. Adamovičs initiated a comprehensive research on all legumes and grasses grown on sod-podzolic and sod-calcareous soils in Latvia. Creating a single-component sward and double- and multi-component (3–6 components) swards on different agrarian backgrounds and applying different utilizaton modes, the agro-technical and physiological aspects of yield formation of the latest grass varieties were examined. The research results were summarised in 157 scientific publications, as well as in reports presented in various international congresses, conferences and symposia. In the course of the 25 research years, an information database for formation of high-performance and high-quality swards and for modeling separate processes in the growth and development of grasses was created. Some of the results were summarised in doctoral theses (Skaidrīte Būmane, Iveta Gūtmane).

Since 2007, under supervision of A. Adamovičs, first studies on the use of various grasses and field crops for production of alternative energy (biogas, bioethanol, solid fuel) sources have been carried out. The results are summarised in numerous publications and books: A. Adamovičs *et al*. "Cultivation and use of energy crops" (2007); A. Adamovičs *et al.* "Biomass: Study course for students" (2011); eds P. Rivža, A. Adamovičs, Z. Gaile *et al.* "Renewable energy and efficient use in Latvia" (2012); V. Dubrovskis, A. Adamovičs "Horizons of bioenergy" (2012); A. Adamovičs "Biomass" (2012).

In 1994, Zinta Gaile started her research in crop production. Within the framework of her doctoral thesis "Evaluation of different selection criteria for maintenance breeding of barley variety 'Klinta'" (defended in 1998; supervisor assoc. prof., Dr. biol. Ina Belicka), she studied initial barley seed production. Also the further scientific activities of Z. Gaile were connected with seed production. She participated in the research carried out by the Organic Seed Production Working Group, whose task was to create a system of organic seed production. For this purpose, in 2002, a certified organic field was arranged at the Research and Study Farm "Vecauce". Also crop varieties of conventional farming were studied: cereals, oilseed rape, potatoes, legumes, grasses.

An extensive research on the use of maize for forage and biogas production was performed at "Vecauce" in 1993–2013. Altogether, hundreds of different maize hybrids were evaluated under various agro-meteorological conditions in order to determine the early hybrids most suitable for

conditions in Latvia, as well as to evaluate other maize hybrid qualities that determine their suitability for forage or biogas production.

Z. Gaile was the first in Latvia who evaluated the maize quality by using the neutral detergent (NDF) and acid detergent (ADF) fiber method. Before the Scientific Laboratory of Agronomic Analyses started doing such kind of analysis, the quality of forage maize hybrids researched at "Vecauce" were analysed in a laboratory of Tartu University, Estonia. Maize fertilisation and weed control were investigated, and studies on the most appropriate sowing and harvesting terms were conducted; besides, in 2008, research on the use of maize for biogas production in Latvia was commenced.

Since 2005, under the supervision of Z. Gaile, different aspects of oilseed rape cultivation have been investigated: effects of sowing date and rate and of plant growth regulators on the formation of two types (hybrid and line) of crop varieties; efficiency of foliar fertilisers; and effectiveness of the proposed fungicides. Studies have been conducted within the framework of internal research projects of the Latvia University of Agriculture, financed by the Ministry of Education (2006–2008), as well as within an ESF co-financed project (2009–2012).

All the long-term research results have been summarised in reviewed scientific papers, as well as in other scientific and popular-science articles.

Research in Soil Science and Agrochemistry

Aldis Kārkliņš

With the beginning of the work of the Rīga Polytechnicum also research in soil science and agricultural chemistry started. In the academic year 1864/65, chemistry professor Augusts Teplers (1836–1912) began to teach agricultural chemistry. He founded the Research station where students were trained in precision farming techniques and where materials used in the production were tested. At the same time, professor Kārlis Loviss (1839–1911) started reading lectures in mineralogy, geology, and soil science. In 1872, G. Tomss (1843–1902) started delivering lectures in the Comprehensive Agricultural Chemistry course at the Rīga Polytechnicum, and became the manager of the Chemical Research Station in 1877. The task of the Station was to control the quality of all fertilisers imported through the Latvian ports and the port of Pärnu, as well as to provide control of the composition of different materials used in agriculture and elsewhere.

In 1874, in different places in Latvia (in Pierīga, near Olaine, in Kuldīga district), field trials were launched to study the effectiveness of fertilisers, bone meal, guano and manure in crop production. In 1877, the Rīga Polytechnicum established the study farm "Pēternieki" ("Peterhof"). There, where G. Tomss carried out detailed examination of the physical and chemical properties of the soils of arable land and grassland, and created the soil maps and the so-called Agronomic Map of arable land. In subsequent years, similar research work under G. Toms's supervision was carried out in a number of manors in Vidzeme and Kurzeme.

In 1880, V. fon Knīrīms began to work in the Polytechnicum as professor in agriculture and also as the manager of the "Pēternieki" study farm, where he organised experiments related to the use of different fertilisers. It can be pointed out that soil, its fertility evaluation and cultivation issues, use of fertilisers, including innovations of that time – mineral fertilisers –, were areas of active research from the first days of the Rīga Polytechnicum – the predecessor of our University. Studies

were practically oriented and well organised, combining the experimental and study work (both theoretical and practical) as well as providing qualified services for the industry.

The graduates of the Chemistry Department of the Rīga Polytechnical Institute (since 1892), who had the opportunity to attend the courses taught by the great Latvian chemist Pauls Valdens made a significant contribution to the Latvian soil science and agrochemistry; they were Pēteris Kulitāns (12.04.1878–06.11.1951), Kārlis Krūmiņš (26.12.1890–31.10.1966), and Kārlis Bambergs (27.02.1894–07.09.1981). All of them worked in close cooperation with the Rīga Polytechnical Institute, later – with the Higher School of Latvia, afterwards – with the University of Latvia, with Jelgava Academy of Agriculture, and, finally, – with the Latvia Academy of Agriculture. The contribution of these professors to the Latvian science, economy, and higher education organisation has been described in separate publications. An extensive field trial network was organized, research of the Latvian natural resources was done, various aspects of soil study chemical analyses were performed, and analytical methods were elaborated by the professors, thus establishing strong traditions in the field of soil science and agricultural chemistry. Still today their books and other publications are used as a classic source of information. Also in this period of time, scientific research was oriented towards both aspects – theoretical studies, and clarification of practical issues.

Together with the above-mentioned professors, Indriķis Hugo Lācis (01.11.1891–17.04.1953) worked in the field of agrochemistry. From 1924 to 1937, he was the manager of Jaungulbene Experimental Station and from 1937 to 1944 – assistant professor at the University of Latvia and Jelgava Academy of Agriculture. At that time in Jaungulbene Experimental Station, numerous experiments on soil liming, fertilisation, and use of manure and green manure were carried out. In the organisation of the experiments and in the evaluation of the obtained results, also K. Bambergs participated.

In the 1919/1920 academic year, P. Kulitāns began to teach agricultural chemistry at the Higher School of Latvia. He was an editor of the book: Bambergs K., Krūmiņš K., Kulitāns P. "Analytical Procedures in Agriculture", Volumes 1 and 2 (1930–1931). This two-volume edition can be considered the first university textbook for students of agricultural chemistry, and it was very useful also to a wider audience, especially for researchers and agronomists, who organised field trials.

In 1939, Jānis Laganovskis (13.01.1915–13.05.2005) started working at Jelgava Academy of Agriculture. He worked there until 1983. J. Laganovskis was a man endowed with a talent of a teacher, a manager, and a disseminator of research achievements. His field of research was horticultural and field crop fertilisation, use of micronutrients in plant production, and other issues.

After the World War II, Latvia Academy of Agriculture was moved back to Rīga. The scientific work in soil science and agricultural chemistry was continued by professors P. Kulitāns, K. Krūmiņš, and K. Bambergs (Snr.); also Jānis Gaross (19.02.1899–11.10.1981) and Ziedonis Maldavs (17.10.1916–16.05.1989) started their scientific career here.

Soon afterwards, post-war graduates who commenced their work at the Department of Soil Science already during their studies joined the Faculty of Agronomy: Rainis Skujāns (06.08.1922–17.02.2011), Henrihs Mežals (19.04.1927–01.12.2012), Kārlis Bambergs (Jnr.) (born 27.01.1928), Visvaldis Freivalds (20.04.1910–30.09.1972), Anda Balode (21.04.1924–23.04.2009), and others. Thus, there was a gradual generational change taking over the traditions and style of work, and ensuring continuity in research. All above-mentioned academic staff members worked at the Department of Soil Science and Agrochemistry for more than 20 years, but some even more than 50 years.

The Scientific Laboratory of Radiobiology of the Faculty of Agronomy (1961–1994) was founded and managed by Z. Maldavs (later – by Andris Bērziņš). The Laboratory researchers working in close cooperation with the Soil Science Department developed a potassium radiometric detection methodology and studied the content of ^{89}Sr, ^{90}Sr and ^{137}Cs in plants and soil. This was particularly topical at that time when the world faced intensive nuclear tests aboveground, in the atmosphere, under water, and underground. Studies were carried out on the use of nuclear radiation in biology: for plant growth stimulation to induce mutation in breeding, for vegetable shelf life extension, etc.

Research topics in the field of soil and agrochemistry in this period of time were different. The research covered both theoretical issues (such as soil genesis and research devoted to exploration of Latvian natural resources) and practical issues topical at that time in the agricultural sector. The research took place in relatively close cooperation with leading research institutes of the USSR. An example would be the numerous so-called network experiments that were made applying the same methodology in many places to explain the effectiveness of fertilisers in different soil and climate conditions. Extensive studies were conducted to test various by-products, as well as to test usefulness of specially produced materials for supplying microelements to plants. Studies on soil fertility evaluation methods and its control, as well as other studies were carried out. In 1977, Aldis Kārkliņš commenced his work at the Department of Agrochemistry and was involved in the research of the use of liquid complex mineral fertilisers, later – in the research of the use of liquid manure and of the optimisation of fertiliser norms and agrochemical parameters of the soil. Roberts Vucāns started to work at the same Department in 1979, and his research interest was issues related to the use of liquid manure.

In the period after 1990, organisation and funding of scientific work, as well as the choice of research topics were radically changed. Scientific communication and coordination, as well as thematic programmes and funding strongly monitored by the USSR central institutions were terminated. A rapid reduction in scientific institutions and employees took place in Latvia; the land on which long-term field experiments were located was privatised, and the funding was dramatically cut. Researchers started looking for opportunities to participate in international programmes, and began to get used to the novelty – work in the form of research projects. Many scientists took the opportunity offered by assistance programmes of the European Union and the USA and participated in internships abroad, in conferences, and in the implementation of various projects. Although the programmes were not focused on the acquisition of new experimental data, but rather on collection of the information and further provision to foreign partners, the experience was gained and the contacts established. The scientists had an opportunity to acquaint themselves with the rules of research organisation under new circumstances and the priorities important for future operation in the unified EU system. During this period, Latvia University of Agriculture was reorganised and the Department of Soil Science and Agrochemistry was established (1993) integrating both disciplines in one unit.

One of the activities important for Latvia's international integration was introduction of international standards in the field of soil information. This included use of proper methods for soil resource inventory and assessment, transition to other analytical procedures, a new approach to data collection and interpretation, introduction of new scientific terminology, as well as inclusion of data on Latvia's soils into international databases. This was time when former USSR approach in the soil science and data processing systems had to be changed to the quite different systems used

in Western Europe, USA, and elsewhere. Therefore, A. Kārkliņš used the opportunities offered by the first foreign partners and participated in the internship at the Swedish University of Agricultural Sciences, at the Royal Veterinary and Agricultural University of Denmark, and in other institutions. He commenced research on the cross-compliance of analytical methods applied in soil diagnosis and on compatibility of the obtained results. Broad researches were carried out in the development of methods for the determination of soil adsorption capacity, and in the possible use of this indicator in the optimisation of fertiliser use and in the assessment of environmental risks.

One of the first major activities in soil research was the soil expedition carried out in the Baltic countries and the USA organised in two rounds, in August 1994 and in August 1996, and covered all three Baltic countries: Latvia, Lithuania, and Estonia; the coordinator was A. Kārkliņš. The objective of the expedition was to intercalibrate the methods of soil survey, the morphological description of the soils, as well as the modern analytical methods in soil diagnosis used in the Baltic countries and in the United States. Next to these activities, in 1995–1996, the project "Soil Classification and Land Evaluation in the Baltic States" was implemented (managed by A. Kārkliņš), within the framework of which two expeditions with participation of researchers from Latvia, Denmark, Finland and Norway were organised: one in Latvia, and one in Denmark.

The accumulated experience as well as newly collected data that complied with international standards allowed the scientists (A. Kārkliņš, H. Mežals, R. Skujāns, and K. Bambergs in cooperation with Oļģerts Nikodemus from the University of Latvia) to participate in the implementation of two major projects. One of the projects was development of the Soil Map of the European Union (scale 1:1 000 000) and information processing for the European Soil Database (European Commission, European Soil Bureau Network), where data on Latvian soils were included in a unified format. The second project was inclusion of the Latvia soil data in the Global and National Soils and Terrain Digital Database SOTER (scale 1:2 500 000), as well as joining the SOVEUR project "Assessment of Soil and Terrain Vulnerability to Pollution in Central and Eastern Europe". The project was implemented by Food and Agriculture Organisation (FAO) in collaboration with the International Soil Reference and Information Centre (ISRIC). The information systems developed within the framework of this project also currently remain the main sources of information for different EU needs. As the result of studies carried out during these projects, several books were published: A. Kārkliņš. "Internationally recognized soil classification systems." – Jelgava: LLU, 1995; A. Boruks, A. Kārkliņš, O. Nikodemus. "Soil research and land evaluation." – Skriveri: LLU, Skriveri Science Centre, LR State Land Service, 2002; A. Kārkliņš. "Guidelines for soil diagnosis and description: Field book." – Jelgava: LLU, 2007; and A. Karklins. "Guidelines for soil diagnosis and description." – Jelgava: LLU, 2008. Besides, A. Karklins was the national contributor to the compilation of "The Soil Atlas of Europe" (European Soil Bureau Network, European Commission, 2005).

The study results in soil science and agrochemistry were presented in A. Kārkliņš' scientific summary for acquisition of Habilitated doctor's degree in 1997 – "Soil resources inventory and fertilizer use according to the Principles of Sustainable Agriculture".

The next scientific work carried out at the Department of Soil Science and Agrochemistry was focused mainly on the improvement of classification of Latvia's soils as well as on comparison of the Latvia classification units with the World Reference Base for Soil Resources and with American "Soil Taxonomy". This work was very important also because use of any soil data Latvia without providing references to a certain internationally recognised soil classification is not acceptable.

Besides, Latvian soil classification system had to be updated, including all soils common in Latvia regardless of the type of land use, and providing their detailed description. In the result, "Taxonomy of Latvia soils" was published – Ed. by A. Karklins / A. Karklins, I. Gemste, H. Mezals, O. Nikodemus, R. Skujans. – Jelgava: LLU, 2009. This is the first such edition in Latvia in the entire history of the soil science in Latvia.

The academic staff of the Department (A. Kārkliņš and Jānis Livmanis) and researchers (A. Vucāns and Irma Gemste) under the supervision of A. Vucāns took active part in the development and implementation of the Three-Level Agricultural Land Monitoring System in Latvia. This project was launched in 1992, and it was intended that in cooperation with the State Land Service the agricultural land would be monitored on a regular basis. The monitoring would cover the following aspects: systematic collection of information on the changes in soil of the agricultural land depending on its diversity and farming profile as well as taking into consideration factors affecting the soil fertility (used fertiliser, agro-technical measures, yield, its chemical composition and quality parameters, etc.). The monitoring system was planned as a thorough and detailed research programme, operating at three levels: 12 stationary study sites, covering a variety of 20 soils; 190 commercial farms; and an annual summary of information on land use in all Latvian municipalities. If implemented, a modern monitoring system developed after the best examples of most developed European countries would be available. The system would give possibility of following up the changes and processes taking place in the area of soil quality and land use. Unfortunately, due to the insufficient funds and unsatisfactory institutional system, the scheduled works were never completed, and, in 2000, this project was terminated without even collecting and analysing the already acquired information. In 2002, the government decided for development of another monitoring system coordinated at the national level, which would ensure monitoring of the soil and land; however, these plans were not carried out either.

Monitoring is still a topical issue because the European Union Soil Thematic Strategy clearly indicates the need for each member state to exercise effective monitoring of national soil resources and identification and mitigation of the land use and degradation risks.

Since 2003, Latvia had the opportunity to gain international support for soil and land resource inventory, for identification of degradation risks, and for elaboration of prerequisites for mitigation of the risks. Within the framework of the UN Development Programme and Global Environment Fund, the projects in the field of "Capacity Evaluation of Latvia in Fields of Biological Diversity, Climate Change and Land Degradation" have been implemented. An international interest group for "Protected Soil in Central and Eastern European Countries (Pro–Soil in CEEC Network)" has been founded. A. Kārkliņš together with O. Nikodemus (University of Latvia) successfully elaborated a project proposal, and, in 2006–2007, a large-scale project funded by the UNDP was implemented in Latvia – "Guidelines for developing OP 15 projects under the Strategic Priority 1: Capacity Building – Building Sustainable Capacity and Ownership to Implement UNCCD objectives in Latvia" GEF/UNDP)". Project objectives and activities were various, but Latvia University of Agriculture and other universities had a possibility of producing a new textbook in soil science: O. Nikodemus, A. Kārkliņš, M. Kļaviņš, V. Melecis. "Soil conservation and sustainable use." – Rīga: LU Academic Publishing House, 2008.

Another soil research project with participation of A. Kārkliņš and J. Livmanis, coordinated by the Latvian State Forest Research Institute "Silava", was implemented in Latvia in 2005–2007 – "Forest soil inventory in the framework of 1st level monitoring sites", which is a component of the

international forest ecosystem monitoring programme FOREST FOCUS 2006 – BIOSOIL. Within the framework of this project, soil reference profiles in different areas of Latvia were studied and described in accordance with the international data acquisition and interpretation methods.

Descriptions of Latvian soil reference profiles in line with internationally recommended methods have been carried out at the Department since 1997, and currently they comprise 106 soil profiles, for detailed examination of which the internationally accepted methodology has been applied. Descriptions give an insight into the diversity of Latvian soils and their characteristics in accordance with internationally applied criteria, allow the data to be included in the international information systems (databases), and help compare the data collected in Latvia to the international standards that should be used for the circulation of information between Latvia and the EU institutions.

Nowadays, standardisation is important not only for the products, but also for the concepts, processes, terminology, interpretation schemes, and evaluation criteria, therefore recently a glossary has been published: A. Kārkliņš. "Soil Science: Glossary of Terms." – Jelgava: LLU, 2012.

At the same time, research in the field of agrochemistry has also been carried out at the Department. In collaboration with colleagues from the Faculty of Rural Engineering (Pēteris Bušmanis, Viesturs Jansons), the Swedish–Latvian joint project "Agricultural Run-off Management Study in Latvia" was implemented, and the effect of the use of fertilisers on the environment was analysed. Work on the development of the rules for Good Agricultural Practice was carried out (in cooperation with Denmark). The relevant rules were published: "Code of Good Agricultural Practice for Latvia." – Jelgava, 1999. Even several years after completion of the project, the work on research and development of regulations has been continuing so that these regulations could be implemented in practical agriculture, and effective measures for identification and control of environmental risks could be developed.

During the time period 1994–2006, researchers Dr. agr. A. Vucāns and Dr. agr. I. Gemste worked at the Department. Owing to them, the Three-Level Agricultural Land Monitoring System was introduced in Latvia, which operated until 2000 (see above). Besides, their merit is also research on the composition and environmentally safe use of sewage sludge. The research results were presented in several publications: I. Gemste, A. Vucāns. "Sewage sludge and possible use." – Jelgava: LLU, 2002; I. Gemste, A. Vucāns. "Sewage sludge." – Jelgava: LLU, 2007; I. Gemste, H. Smilga, J. Ventiņš. "Sewage sludge and soil." – Jelgava: LLU, 2009; and I. Gemste, A. Vucāns. "Sewage sludge." – Jelgava: LLU, 2010.

In 1998–2000, Department staff members took part in the implementation of the internationally funded project "Managing Inputs of Nutrients to Avoid Insufficient or Excess". Our partners were colleagues from the United Kingdom, Poland, the Czech Republic, Slovakia, and the Netherlands. The project was dedicated to the development of recommendations for ecologically balanced use of fertilisers. Within the framework of this project (A. Kārkliņš, Ināra Līpenīte), studies were organised in six Latvian farms, where, in the course of five years, analysis of farm commercial activity was performed and the annual balance of nitrogen, phosphorus and potassium was calculated, applying an internationally recommended calculation methodology. This gave an overview of the flow of these nutrients in farms of different specialisation. The overview of each of the study farms was published in the Proceedings of Latvia University of Agriculture (2005–2007). At the same time, within the framework of the above-mentioned and another international project (in collaboration with Danish specialists), chemical composition of crops and manure was studied, methodology of manure output

and its value assessment was worked out, and recommendations for assessment and mitigation of environmental risks due to the fertilisation were proposed. These studies had practical orientation, were carried out to improve provision of information to farmers – on soil fertility control and on fertilisation planning, and were conducted in collaboration with other Latvian research institutions and with the Latvian Agricultural Advisory and Training Centre. The study results were published in scientific periodicals and were presented in the textbook: "Crop Science and Production", ed. by A. Ruža – Jelgava, 2001 and 2004.

Issues pertaining to the use of fertilisers have been studied in the Research farm "Peterlauki" from 1996 to 2009 (R. Vucāns, I. Līpenīte, J. Livmanis). In the six-field crop rotation in Endogleyic Stagnosol, the following crop rotation was introduced: winter wheat – green manure (oil radish) – spring wheat – barley – barley + clover – first year clover. Such crop rotation was considered the most preferable in farms specialising in crop production (cereal production) in Zemgale. The objective of the researches was to examine the efficiency of the use of increased dosages of nitrogen and phosphorus in the crop rotation. Also the following issues were clarified: the preferred fertiliser norms, their impact on crop yields, crop quality, as well as agronomically desirable nutrient balance that should be provided in farms of the above-mentioned specialisation, particularly if they are located in the so-called vulnerable areas.

In 2006–2007, A. Kārkliņš participated in the international project "Environmental Assessment of Soil for Monitoring", which involved altogether 36 soil research institutions from different EU countries. The project was aimed at developing common EU principles, criteria and methods for soil monitoring in order to track the changes in soil quality and the possible degradation risks, as well as to assess the sustainability potential of soil resources. These activities were a direct continuation of the "Thematic Strategy for Soil Protection" adopted in the EU, as well as the preparatory phase for the forthcoming Soil Protection Directive in order to identify the opportunities for its implementation and elaborate its methodical substantiation.

Since 2001, A. Kārkliņš is the national representative in the European Soil Bureau Network. The role of this structure is to provide information compliant with the international standards to the European Soil Data Center (ESDAC), to provide consultations to this Centre, as well as to ensure cooperation in the implementation of European-level projects. ESDAC, in its turn, provides information for the EU institutions that require such information for making political decisions and for providing support in soil-related and other issues.

In 2009–2012, extensive studies (A. Kārkliņš, I. Līpenīte) on change in soil properties related to the non-traditional agricultural land use were carried out. The following activities were considered as non-traditional agricultural land use: afforestation (the main focus), energy crop plantations, and long-term repeated sowing of the same crop group. The research took place in several places in Latvia in collaboration with researchers (Mudrīte Daugaviete, Dagnija Lazdiņa) from the Latvian State Forest Research Institute "Silava"; under their supervision, plantations of pine, spruce and birch had been created on former agricultural land several years before. The objective of the research was to explain how by changing the land use and turnover of organic matter and nutrients, physical and chemical properties of soil are affected. The research is being continued by the doctoral student Sarmīte Rancāne in the stationary research base in Skrīveri.

In 2003, Ilze Vircava commenced her work at the Department. Her research direction was Latvian clay minerals and clay genesis and characteristics, as well as the different structures of

illite and their inheritance in glacigenic sediments. I. Vircava was involved in intensive cooperation with researchers from the University of Latvia and the Riga Technical University, as well as with foreign partners. Her study results are summarised in her doctoral thesis "Iillite structures in the glacigenic sediments of Latvia", which was successfully defended at the University of Latvia in 2010.

Certain scientific developments have also taken place in the horticultural sector. In 2012, Valentīna Surikova successfully defended her doctoral thesis "Nitrogen, phosphorus and potassium requirement for apple cultivar 'Melba'" (scientific advisor A. Kārkliņš). Her research performed in the stationary research base of the State Institute of Fruit Growing in Dobele, and was aimed at explaining the specifics of intensive apple tree fertilisation combining fertilisation with different soil moisture control measures (mulching, drip irrigation) and with the influence of the grass growing between the rows of apple trees.

Doctoral student Jana Apše has focused on Northern highbush blueberry cultivation and fertilisation issues, which she started to study already in her Master's degree paper.

For his achievements in scientific work, A. Kārkliņš became the winner of the competition "Sējējs 97", organised by the Ministry of Agriculture and the Ministry of Environmental Protection and Regional Development in 1997. In 2011, he received Paulis Lejiņš award, granted by the Latvian Academy of Sciences and the Latvian Academy of Agricultural and Forestry Sciences, for the collection of his works "Development of integrated soil information system of Latvia".

Optimisation of Elements for Soil Management Systems

Dainis Lapiņš

The scientific objective of soil management has always been development of scientifically sound recommendations for resource-efficient and environment friendly crop production technologies. To structure the overview, time periods related to World War II as well as research themes of scientists and doctoral students working in the respective periods in Latvia are used. Owing to the use of the GPS and sensor technologies, new work elements appear in crop production technologies in Latvia at the beginning of the 21st century. The present publication has the following tasks: explanation of the historical research carried out in Latvia University of Agriculture Faculty of Agriculture in the field of substantiation of plant rotation, minimisation of soil cultivation, as well as weed distribution and optimization of the control.

Time period: 1922 – 1950. The scientific work of the Department of Soil Management, which was founded in the Faculty of Agriculture of the Latvia University (LU) in 1922 with location in Rīga, was supervised by professor Jānis Apsīts. With small interruptions, scientific work under his supervision continued until 1948. Until 1921, the main research basis of the Faculty of Agriculture as well as of the Department of Soil management was located in Vecauce. The research was focused on issues related to agrophysical characteristics of soil, soil tillage and technologies, soil cultivation and sowing systems, as well as weed biology, distribution and restriction. Professor J. Apsīts collected the main results obtained not only in Latvia, but

also in Europe in his book " Soil management", which later had three editions. The scientific publications were included in the "Collection of articles" published at LU; from 1939 to 1944, the editor in chief was professor J. Apsīts.

Time period: 1950 – 1990. At the end of the 1940s and at the beginning of the 1950s, the main research area of the Department of Soil management was weed distribution control. Research on the couch grass and field dodder biology and control methods was carried out by Semjons Pogodins and Jānis Tomsons (Higher Agricultural Education ..., 1999). Also research in soil tillage was taken up anew: preferences and significance of perennial grass sod ploughing time (Jevgeņijs Rubenis); and effects of the intensity of line spacing tillage on characteristics of both mineral soil and crops – sugar beet, maize, spring barley, and oat (Jānis Klovāns, Rūta Kroģere, Raimonds Jansons, Jāzeps Laganovskis).

In the Radiobiology Research Laboratory of the Department of Soil management and Soil Science, studies of the effect of seed pre-sowing gamma radiation on carrot yield and quality were carried out (A. Bērziņš).

Starting from 1966, research in the area of scientific basis of field crop rotation was launched. This complex theme investigated the significance of the choice of pre-crops for growing red clover, winter wheat, winter rye, spring barley, oats, peas, fodder beans, potatoes and sugar beet using the same crops as pre-crops. Field studies were arranged in three different soil conditions; however, all above-mentioned crops were grown in sod carbonate soils also in non-changing sown areas. Agro-physical soil properties, weed infestation and biological activity of soil were investigated as crop yield affecting factors (J. Rubenis, Jānis Strazds, Jānis Kārklis). In the research on the role of forage crop rotation in sod carbonate heavy loam soils, the significance of the rotation period of winter intercropping for winter rye fresh material and subsequent post-harvest main crop (fodder kale and winter rape fresh material) and for vetch mix fresh material as pre-crop (in two varieties of forage barley, fodder beets, winter rape, and vetch mix fresh material) was explained. In the four-year forage crop rotation stages, the significance of the use of red clover as pre-crop was evaluated (Dainis Lapiņš). The research also covered the issue of stubble intercultural exchange and variety effects on the re-sown spring barley yield (Dzidra Strade). On the basis of the accumulated experimental results in Latvia, an issue related to the planning and development modules of the crop rotation system, depending on the crop specialisation and technological conditions of soil, was discussed (Imants Ivulāns, R. Kroģere).

In the late 1970s, issues related to complex crop rotation, soil tillage and weed control measures became increasingly topical; therefore, in 1982, a cereal–grass crop rotation stationary was arranged in sod carbonate heavy loam soils. In soil tillage systems, also variations with annual shallow basic treatment of soil in the fall compared to the annual stubble or sod inversion in rotation cereals–grasses were included (R. Kroģere, Vladimirs Bohans).

In the studies of harmonisation of mechanical and chemical techniques of weed control in repeatedly sown spring cereals in sod carbonate soils, also different stubble ploughing and spring cereal cultivation technologies were evaluated (Maija Ausmane, Indulis Melngalvis). It was concluded that annual ploughing in sod carbonate soil conditions in a stationary of a specialised six-field cereal–grass crop rotation without a significant yield reduction can be replaced by a single ploughing in a crop rotation period, and in the remaining years – stubble ploughing at the depth of 10–12 cm. Replacement of ploughing with shallow tillage leads to differentiation in the

topsoil fertility indicators, including the amount of organic matter. Minimisation of soil tillage does not give significant changes in the number of short-lived weeds in cereals. By refusing from ploughing in all cereals, the number of perennial weeds increased by 28% compared to annual ploughing. By shallow ploughing, weed seeds are accumulated in the topsoil, and the largest part of them germinate already the next year. Minimum soil tillage changes the composition of weeds in agrophytocenosis; also weed composition often changes regardless of soil tillage system. Meteorological conditions have a great influence in this respect. Shallow soil tillage compared to annual ploughing contributes to increase in the number of soil clods after the pre-sowing treatment.

During the crop rotation in conditions of annual ploughing, the storage volume of the lower layer of topsoil often exceeds the optimum and approaches the equilibrium density level, while a higher soil microbiological activity is observed in re-tillage of perennial grasses (Juris Liepiņš, M. Ausmane, R. Kroģere, I. Melngalvis).

In 2000, the Department of Soil management completed the permanent stationary experiments for optimisation of soil tillage system in crop rotation.

In the time period 1990–2000, the Department of Soil management researched the following scientific themes in the area of weed distribution and weed control: comparison of the efficiency of harrowing and herbicide use in spring barley; and the effect of wild oat *Avena fatua* L. on spring barley yield, and the problems related to restriction of its spread (D. Lapiņš, A. Bērziņš, Anita Sprincina and others).

Weed infestation records were kept in stationary observation areas in farms in Kurzeme and Zemgale. The records showed that farms widely used re-sowing of cereals and that 50% of the spring wheat were re-grown. In grain sowings where herbicides were used, compared to the areas where they were not applied, the number of certain weed species had increased: In spring wheat these species were *Viola* sp. and *Fallopia convolvulus* L., while in spring barley – *Veronica* spp. A high weed infestation was observed also in perennial grasslands, with many of the species being poisonous for livestock. Studies on the composition of weed species showed that over the last 50 years, certain weed species no longer existed in sowings and that they required special gene-pool protection measures.

One of the reasons for enlarged spread of short-lived monocotyledonous weeds *Avena fatua* L. and *Apera spica-venti* (L.) Beauv. is repeated and non-changing cereal crops (D. Lapiņš, Jeļena Koroļova). Research in weed infestation monitoring in farms in Latvia regarding weed dynamics and control options in Vidzeme cereal sowings were continued (Ineta Vanaga). In biological farming systems without use of herbicides and fertilizers, a lot of attention should be paid to crop rotation and soil tillage, to harmonisation of sowing activities, as well as to ensuring crop competitiveness with weeds (M. Ausmane, I. Melngalvis).

The effect of reduced herbicide dosages on weed infestation in spring barley and weeds was examined within the framework of an international project. Vegetation trials in Denmark studied post-effect of a reduced dosage of herbicides on short-lived weeds, first of all on the sensitivity of white lambsquarter next generation sprouts against herbicides. (Jānis Kopmanis).

The spread of the invasive weed Giant hogweed in Latvia was identified, and, on the basis of tests carried out in four areas, recommendations for the use of mechanical, chemical, biological and complex measures for reducing the prevalence of this weed were elaborated (A. Bērziņš, Aigars Oļukalns).

The results of research on the use of herbicides in perennial legume (red and white clover, hybrid lucerne, and fodder galega) sowings were summarized. They showed that in two different soil types in the sowing year the highest efficiency was reached by using a mixture of herbicides: synergists pendimethalin and bentazone. The positive post-effect of the use of herbicides was recorded also in the first year. The negative phytotoxic effect of herbicides on legumes was compensated with a positive effect of the reduced weed infestation.

The use of herbicide reduces the closeness of linear relationship between the above-ground mass and roots mass of legumes. Phytotoxic effects of herbicides on the development of herbaceous perennials are determined also by the soil type and grading composition; however, the grass species and variety are no less important.

Tetraploid red clover is more sensitive to herbicides than diploid clover. Analogue experiments on the post-effect of the herbicide use in seven species of perennial grasses explained the effect of herbicides: bentazone, MCPA, as well as grodyl mixture with MCPA. Phytotoxicity of MCPA, bentazone, amidosulfuron and metiltribenurona for different species of perennial grasses (orchard grass, perennial ryegrass, meadow foxtail, timothy, perennial ryegrass, festulolium, meadow grass) is not equal. It has been established that the herbicide with the lowest phytotoxic post-effect on grasses is MCPA (D. Lapiņš, A. Bērziņš, A. Adamovičs).

Research on the combined effect of soil tillage, sowing, and herbicide use in winter wheat after various pre-crops at the Research and Study Farm "Vecauce", and in repeated sowing after winter rape was carried out also in sod-carbonate soils in company "Dobele Agra" from 2001 to 2005. It was established that the effect of weed control and herbicide use on variations in winter wheat yield was significantly larger than that of the use of soil tillage, i.e., sowing and pre-crops (Ēriks Stašinskis).

Researches showed that deep ploughing in winter wheat was more effective than in spring barley. Besides the significant positive impact of deep ploughing in winter wheat, also increase in yield in the following year was observed in repeated wheat sowings. Marl formation with deep ploughing of subsoil decreased soil resistance only in up to 15% of the area; in the remaining area, between the ripper tines with a 1.8-m distance, the soil resistance either did not change significantly or even increased. In spring barley where the soil was not inverted, the yield decreased significantly. Glyphosate formulations used in autumn for weed distribution control reduced the significance of the difference between the sowing options with and without soil inversion.

Both in 2005 and 2006, with the dramatic moisture deficit in the soil during and after the spring barley tillering phase, the soil moisture was significantly lower at all relevant depths within 0–45 cm compared to the variants without plants; it was accompanied also by a significant increase in soil penetrometer resistance in spring barley compared to the variants without plants. The relationship between soil moisture and its resistance is characterised by linear correlation, whereas the relationship between soil moisture, soil resistance, and yield is characterised by multifunctional correlation that determines usefulness of the research of partial correlation relationship (D. Lapiņš, A. Bērziņš, J. Kopmanis, Renāte Sanžarevska).

Since 2004, an integral part of the work of the Department of Soil management of the Institute of Soil and Plant Sciences is the use of the GPS, GIS, sensors, and other state-of-the-art technologies. The main objective of the scientific work has been to obtain scientific substantiation for the difference

of technologies in areas with uneven soil fertility indicators. It was established that in the decision-making system for soil tillage difference, an essential role in winter wheat yields was played by the organic matter content in soil, by the thickness of Ap horizon, and by the values characterising the relief. In field studies with stationary GPS observation points in moraine hills, the effects of soil heterogeneity and differences in the relief on winter wheat (*Triticum aesativum* L.) yield, which was characterised by multicolinearity, as well as the need for partial correlation relationship studies was confirmed (Gundega Dinaburga (Putniece)).

The studies of the Institute of Soil and Plant Sciences, including Division of Field Management, in the Research and Study Farm "Vecauce" continued through the observations and analysis of the results in areas with moraine hills typical of Latvia in stationary GPS points that were created in the time period from 2004 to 2007. During 2010–2013, studies and publications focused on the characteristics of relief and subsoil, as well as on weed infestation in the formation of difference between the yields of winter wheat and winter rape (D. Lapiņš, J. Kopmanis *et al*., 2012).

Since the 1940s, extensive research data, though often not thoroughly understood and employed, has been accumulated at the Department of Soil management. Cooperation between different scientific disciplines has an increasing significance in the implementation of environment friendly and economically sound soil tillage as well as of weed distribution restriction measures. Resource-efficient technologies require the scientific substantiation based on the research of the influence of factors determining plant growing and yield formation, taking into account that these factors are often multicolinear.

Theses defended after 1990

1. Ausmane M. (1993). *Integrated Use of Mechanical and Chemical Weed Control for Spring Grain Crops Grown Repeatedly*: summary of the dissertation for the scientific degree Dr. agr. Jelgava: LLU. 34 p.
2. Kopmanis J. (2005). *Effect of Reduced Herbicide Dosages to Weed Infestation in Spring Barley and Next Generation of Weeds*: summary of the dissertation for the scientific degree Dr. agr. Jelgava: LLU. 50 p.
3. Vanaga I. (2010). *Dynamics of the Distribution of Weeds and the Possibilities of Their Control in Cereals in Crop Rotations in Vidzeme*: summary of the doctoral thesis for the scientific degree Dr. agr. Jelgava: LLU. 58 p.
4. Dinaburga G. (2011). *Soil Heterogeneity and Topography Effect on Winter Wheat* (*Triticum aestivum* L.) *Yield*: summary of the doctoral thesis for the scientific degree Dr. agr. Jelgava: LLU. 50 p.

Scientific books published after 1990

1. Lejiņš A., Rasiņš A., Āboliņš J., Gavrilova G., Lapiņš D., Ozols J., Vimba E. (1997). Dictionary of weed, weed group and plant protection technologies. Skrīveri. 300 p.
2. Lapiņš D. (1998). Weeds and Their Prevention. Jelgava: Ozolnieki. 135 p.
3. Lapiņš D., Kažotnieks J. (1998). Soil Cultivation. Ozolnieki: Latvian Rural Advisory and Training Centre. 97 p.
4. Lapiņš D., Kažotnieks J. (2002). Crop Production. Ozolnieki: Latvian Rural Advisory and Training Centre. 247 p.

5. Bērziņš A., Lapiņš D., Lejiņš A., Kukle I., Gavrilova G., Priekule I., Vanaga I., Treikale O., Liguts V., Oļukalns A., Riekstiņš A., Karpenskis G. (2007). Giant Hogweed, Distribution Control: informative material. LR Ministry of Health, LR Ministry of Agriculture, Latvia University of Agriculture, Latvian Environmental Protection Fund. 51 p.

Education and Science of Plant Protection over the Years

Ināra Turka, Biruta Bankina

Plant protection is an integrated science based on the knowledge in entomology and plant pathology, with the main objective to ensure that crop pest and disease control is carried out in line with the latest scientific achievements. The history of plant protection education and science in Latvia stretches back for more than 90 years and, over the time, with the changes in the type of management and political systems, various studies and study programmes in the field have become very topical. In this paper, historical background of the development of plant protection is described in three periods: from 1920 to 1991, from 1991 to 2004 (before accession to the EU), and from 2005 until today.

Period from 1920 to 1991. Plant protection research originates back to 1920, when the Department of Plant Pest and Diseases was created at the Faculty of Agriculture (head of the Department from 1920 to 1926 – Jānis Bickis). Weed research and control was traditionally carried out by field management specialists, and historically it has never been included in the responsibility of the departments related to plant protection.

To describe the history of plant protection, the first encyclopedic edition "Higher Agricultural Education in Latvia" published at the Latvia University of Agriculture (LLU) in 1999 should be mentioned. The information collected in the book successfully represents the continuous changes in the field.

After 1926, the Department of Plant Pests and Diseases was renamed the Department of Plant Diseases (Head of the Department from 1926 to 1944 – Maksis Eglītis, Rector of Jelgava Academy of Agriculture in 1944). He studied crop and tree diseases, draw up the descriptors of plant diseases (1928), and wrote the first textbook in phytopathology: "Plant diseases" (1938). From 1945 to 1949, the Department was managed by Laimonis Pētersons.

During this time, entomology was taught at the Department of Zoology (head of the department from 1945 to 1949 – Egons Tauriņš). For one study year, 1948–1949, the Department of Entomology existed at the Academy, and was managed by Karlīna Priedīte. In 1949, the Department of Phytopatology was incorporated into the Department of Entomology (head of the Department – L. Pētersons); in 1953, the Department of Zoology was added to this Department and was named the Department of Zoology, Entomology and Phytopatology (head of the Department from 1953 to 1957 – L. Pētersons, from 1957 to 1962 – E. Tauriņš).

The Plant Protection Department was established in 1962. Heads of the Department were L. Pētersons (1962–1963; 1965–1970); Česlava Tima (1963–1965), Arturs Priedītis (1970–1997), and Ināra Turka (1997–2005).

In 2005, the Institute of Soil and Plant Sciences was founded, and the Plant Protection Department was included in the structure of the Institute, where it operates also today.

During this time, students were taught the following subjects: 1920–1945 – plant pests; 1920–1945 – plant diseases; from 1945 – agricultural entomology, forest entomology, phytopathology, forest phytopathology; from 1965 – plant protection; and from 1995 – integrated plant protection.

For more than 20 years, the following academic staff members have worked for the Department: asist. Mirdza Seržāne, doc. Vera Pūtele, prof. Edgars Ozols, sen. lect. Valija Apele, prof. Biruta Bankina, doc. Elga Priedīte, doc. Elga Plīse, lect. Māra Kilēvica, prof. A. Priedītis (Priedīte), and prof. I. Turka.

Particular attention in the early 1960s was paid to plant and insect virus diseases. In 1961, the Laboratory for Plant and Insect Virus Diseases was established at the Department of Entomology and Phytopathology (scientific supervisor L. Pētersons, from 1974 – A. Priedītis; Head of the Laboratory – senior researcher Uldis Miglavs). Later, the Laboratory belonged to the Department of Plant Protection. The following senior researchers worked at the Laboratory for many years: Ivars Zariņš, Edmunds Putnaērglis, Imants Damroze, Jānis Ignašs, I. Turka, Guna Eglīte, Līga Dzirkale, Irēna Rituma, M. Kilēvica, and Jānis Plīsis.

The infrastructure, state-of-the-art equipment, and progressive scientists of the Laboratory promoted extensive research in plant protecion. Studies of different directions were conducted in the laboratory, in field trials, and in expeditions, as until then there was no background information available in Latvia for plant virus researches. The following themes were researched:

- virus diseases in crops (potatoes, fruit trees, berries, vegetables, ornamental plants, and ligneous plants), and diagnosis (U. Miglavs, J. Ignašs, I. Turka, E. Putnaērglis, Ēvalds Dreimanis);
- obtaining of virus-free healthy plants (U. Miglavs, Ilze Žola, J. Plīsis);
- virus diseases of forest pests, and plant protection means for control of forest pests (I. Zariņš, I. Rituma);
- insect vectors of plant viruses, and monitoring of aphids and *Acetropa carinata* (I. Damroze, I. Turka);
- extraction of antiserum, biochemical studies, and use of entomopathogenic virus preparations (G. Eglīte, L. Dzirkale, I. Rituma).

Plant and insect viruses were diagnosed with available diagnostic methods, applying indicator plants, electron microscopy, and ELISA test, since the molecular methods in plant virus research were not available at that time. For crop recovery, a tissue culture (meristem and callus) was used, cultivating it *in vitro* in the culture medium suitable for each crop. The research work was focused on the improvement of the general propagation methods and on the elaboration of protocols for propagation of specific plant species. Maintenance of special laboratories required serious investments, and, at that time, the newly opened Laboratory had no problems with investments; however, in 1992, due to the termination of funding, the Laboratory was closed.

Period from 1991 to 2004. Biology of crop pests and diseases, ecology, monitoring of aphids, and pathogen diagnostics and control are the most important directions of research in the plant protection sector both historically and today. However, after Latvia regained independence, with changes in the form of agricultural production and management, new plant protection legislation was adopted. Consequently, the nature and content of the agronomic education and advisory system, as well as the plant protection system changed. There was a transition from a planned large-scale, routine plant protection to a planned specific-for-each-field plant protection for each specific field with a different range of available plant protection products. Today's advanced agriculture has become increasingly dependent on the results of scientific research, on business information, and on services.

Scientists of the Agricultural Faculty of LLU started to search for contacts abroad. In 1995, the period of international research projects started in Latvia, plant protection information and advisory system changed from intensive, chemical plant protection to integrated plant protection. Already at that time, the integrated plant protection system was the recommended plant protection direction and method in the majority of the European countries not only for protection of orchards and vegetables, but also for protection of cereals and potatoes.

The first contacts in plant protection were established in 1992 with the Swedish University of Agricultural Sciences. The first cross-border cooperation project "Forecasting and warning methods in plant protection in Latvia" was launched between the LLU Plant Protection Department, State Plant Protection Service (former State Plant Protection Station), and the Information Centre of the Swedish University of Agricultural Sciences in 1994. The objective of the project was to research crop pest monitoring methods and analyse data in order to develop a forecasting and warning system of crop diseases and pests, which had to be implemented from 1995 to 1998. Within the framework of the cooperation project, the previous recording system of harmful organisms was amended and the recording methods and protocols were unified. Computerised data processing was launched in line with the new principles.

Financed by Sweden, two fixed Rotamsted suction traps for monitoring of aphids were set up in Priekuli and Saldus, which operated successfully for 10 years. Mainly the aphid species harmful to cereals, potatoes and vegetables were identified by recording their development trend. The collected data was used by the experts of the forecasting service as well as by the LLU doctoral students in their research work, when carrying out correlation analysis between potato and cereal virus diseases and their aphid vectors.

In the suction traps, also comparative monitoring of frit flies was carried out and the risk threshold for frit flies was identified. Applying the equation for calculation of degree days, the risk threshold of the frit flies *Oscinella frit* and *Oscinella pusilla* can be forecasted, and, consequently, also the pest control time can be calculated. The studies showed that frit fly damage is possible if the sum of temperatures from the moment of crop germination until the two-leaf stage reaches 80–90 degree days. The programmes currently used in the local meteorological stations already contain the option of degree-day calculation, therefore there is no need to do it additionally. Crop pest invasion and critical thresholds have been investigated by professor A. Priedīte. He, too, in his work emphasises that specific accounting methods and precise time tracking must be applied to each crop and each crop pest. Special attention has been paid to risk thresholds for cereal, legume, potato, brassica, beet, flax, carrot, apple, and berry pests.

Once the project ended, also the funding was cut.

The second cooperation and research project with the Swedish University of Agricultural Sciences was "Barley yellow dwarf virus epidemiology studies in Latvia and Sweden", which lasted from 1999 until 2004. The project was carried out with the financial support from the Royal Swedish Academy of Agriculture and Forestry research programme "Sustainable use of natural resources". Both countries were interested in successful studies in the field of Barley yellow dwarf virus. Within the framework of epidemiology studies, the virus strains and distribution were determined, as well as the possible sources of the virus in nature and its effect on the yield were identified. Also in this project, the data obtained from the suction traps were used to determine the migration of aphids, and hence virus disease outbreaks, as cereal aphids are the vectors of this virus in nature (I. Turka, Māris Bisnieks, and Roland Sigvald).

Inga Moročko implemented the cooperation project "The Role of entophytic and non-pathogenic Fusarium fungi in cropping systems" at the Swedish University of Agricultural Sciences. *Gnomonia fragariae* is an important but little studied strawberry stem base rot causal agent, which until then had been found neither in Latvia nor in Sweden.

In 1998, cooperation with the colleges abroad expanded. An intergovernmental cooperation agreement between the Danish Institute of Agricultural Sciences and Latvia, Estonia and Lithuania was concluded. In 2001, additional project "Decision support systems for implementation of integrated plant protection system in Latvia" with the Polish scientific institutions was conducted. To implement this project, computer models developed by Danish scientists were applied: NegFry model for forecasting the development of potato late blight *Phythopthora infestans* (Mont.) de Bary, and PC-Plant Protection model for forecasting the development of cereal diseases.

Period from 2005 until present. Next to the study work, research is currently carried out very actively at the Plant Protection Department. Research in entomology and integrated plant protection is done under the supervision of professor, Dr. habil. agr. I. Turka. An essential part of plant protection is an accurate and fast diagnosis of harmful organisms. I. Turka in cooperation with Master students has clarified the application of express methods of potato tuber disease diagnostics. Professor, Dr. biol. B. Bankina, and docent, Dr. agr. Gunita Bimšteine investigated various crop diseases and their causal agents, mostly pathogenic fungi. Successful operation would not be possible without the Plant Pathology Laboratory, headed by Mg. agr. Ingrīda Neusa-Luca; a great work has been done by senior laboratory assistants Dzintra Celmiņa and Tatjana Dubrovska. Despite the small staff, the research is done in several directions, mainly depending on the producers' needs and the challenges arising from the intensification of cultivation and in the result of the global trade. The results are determined by successful cooperation with Research and Study Farms "Vecauce" (Z. Gaile and Oskars Balodis) and "Pēterlauki" (Dz. Kreita and Merabs Katamadze), State Plant Protection Service, Latvian Plant Protection Research Centre (Ilze Priekule), Plant Breeding Institute (Arta Kronberga and Aina Kokare), Cereal Breeding Institute (Solveiga Maļecka) and Pūre Horticultural Research Centre (Līga Lepse). Separate studies have been conducted in collaboration with Inese Kokina from Daugavpils University and with Signe Tomsone and Inga Apine from the Botanical Garden of the University of Latvia.

Research of crop pests

The cooperation programme financed by the Latvian Council of Science "Identification of risk factors of plant health and plant protection" (2006–2009) investigated the most important risk factors for growing agricultural crops, for technologies of raw food and for preparation of forage in order to scientifically justify the options for reducing and mitigating the effects of these factors in sustainable agricultural systems. The research examined the influence of separate risk factors on the potential productivity and quality of cereals, tubers, root crops, and grassland in the agroclimatic conditions in Latvia. The economic and biological risks for potential growing of genetically modified crops were evaluated.

In collaboration with the Swedish University of Agricultural Sciences, the role of cereal aphid virus transmission in Latvia was studied.

In recent years, American large-fruited cranberries have been grown in Latvia, therefore activity of pests has increased. The research shows that economically the most important pest of American large-fruited cranberries is tipworm *Dasineura vaccinii* S. Within the framework

of the research, the development trend was studied, providing answers to many complicated control issues (Ilze Apenīte, I. Turka).

In its turn, with regard to field crops, remarkable increase in the sown area of winter and spring rape has been registered during the last few years. Latvia is an appropriate place for successful cultivation of oilseed rape: favorable climatic conditions and suitable soil. Currently, oilseed rape has rapidly taken a significant part in the structure of crops cultivated in many farms. During these years, farmers have already acquired many oilseed rape cultivation characteristics; however, with expanding areas and climatic changes in the past few years, pest infestation has also increased. Information on the destructiveness of crucifer pests, their life cycles, and composition of species in the agroecological conditions in Latvia has been insufficient to ensure successful control. To restrict crucifer pests, farmers use foreign plant protection systems that, in most cases, are not suitable for the agroecological conditions of Latvia. For the first time in Latvia, Ingrīda Grantiņa, under the supervision of I. Turka, identified the stem and seed weevil (*Ceutorhynchus* spp.) species in winter rape. She investigated the life cycle of stem and seed weevil (*Ceutorhynchus spp*.) and brassica pod midge (*Dasineura brassicae*) under Latvia's agroclimatic conditions, evaluating the level of pest harmfulness.

Studies are initiated (Jānis Gailis) on the influence of conventional and minimum soil cultivation and of rotation of different field crops on the densities of natural enemies of crop pests, indicators of sustainable agriculture – Carabidae (*Coleoptera: Carabidae*) and rove beetles (*Coleoptera: Staphylinidae*) – in winter wheat.

Research of crop diseases

From the end of the 1990s, particular attention has been paid to epidemiological studies in diseases of cereals, and later also in oilseed rape. Under the supervision of B. Bankina, extensive research on cereal diseases has been conducted. The spectrum of wheat diseases, their occurrence and potential harmfulness have been identified. The most important yield losses in wheat and barley sowings are caused by leaf blotch diseases, but, in the last decades, two significant diseases – mildew (*Blumeria graminis*) and rusts (*Puccinia* spp.) – have been observed; however, they do not reach a significant level of development.

Tan spot of wheat leaves, caused by *Pyrenophora tritici-repentis,* was not found in Latvia or in Northern Europe before the mid-1990s, but currently it is the prevalent wheat disease in Latvia. Another important disease is Septoria leaf blotch, caused by *Zymoseptoria tritici* (previous name *Septoria tritici*); its life cycle is different – up to now, the pathogen's sexual stage has not yet been found. The biology of this disease and pathogen development cycles have been investigated, sexual stage of *Pyrenophora tritici-repentis* has been found and described, and critical periods of disease development have been determined. In barley, depending on the variety and year, dominant diseases are *Pyrenophora teres* and/or mildew (*Blumeria graminis*).

The situation is different for winter barley – its dominant and most harmful disease is leaf scald, caused by *Rhynchosporium graminis.* Research on the optimal use of fungicides in cereals has been carried out. In cooperation with the Plant Breeding Institute and the Cereal Breeding Institute, harmfulness of rye and triticale diseases as well as possibilities for their control is being evaluated.

Answering producer needs, topical issues are being solved. Factors contributing to the formation of rye ergot (*Claviceps purpurea*), as well as its control options have been identified (B. Bankina).

Since 2006, oilseed rape diseases are researched under the supervision of B. Bankina. Diseases that occur in rape under Latvia's conditions have been identified, and their harmfulness has been measured. The most common disease is rape stem cancer caused by two morphologically similar fungi from *Ascomycota: Leptosphaeria maculans* and *Leptosphaeria biglobosa.* The disease cycle has been described for the first time in Latvia, and the existence of both pathogens has been proven.

White rot (*Sclerotinia sclerotiorum*) does not reach a significant level each year; however, potentially it is very harmful. White rot can be controlled only during flowering before visible symptoms occur, therefore research is carried out to adapt the forecasting systems for conditions of Latvia.

Under the supervision of G. Bimšteine, research on distribution and control options of vegetable diseases has been started in Pūre Horticultural Research Centre. The research is very important, because such studies have not been carried out for decades in Latvia, and disease causal agents as well as their spectrum have changed significantly.

Additionally to the projects, also theoretical studies are carried out; the most important of them is research on the systematic changes in *Ascomycota* phylum *Erysiphales* order, and the identification of mildew causal agents in strawberries and rhododendrons.

Fruit tree diseases have been studied in a number of doctoral theses undertaken in the last years. In co-operation with the State Institute of Fruit-Growing, biology studies on pear rust (*Gymnosporangium sabinae*) have been launched (Baiba Lāce). Diagnosis of large-fruited cranberry diseases and berry rot causal agents (Līga Vilka), as well as biological and ecological research of pear scab (*Venturia pirina*) (Regīna Rancāne) are carried out in collaboration with the Latvian Plant Protection Research Centre.

In 2010, studies were initiated on the spread of wheat stem base and root rot in relation to soil tillage and crop rotation. For the first time in decades, the identification of disease causal agents was started (B. Bankina, G. Bimšteine). It was found that the most common diseases are caused by fungi of the genus *Fusarium*. Applying the molecular methods, the pathogen was identified in cooperation with the Latvian Biomedical Research and Study Centre (Dāvids Frīdmanis and Iveta Vaivade).

The occurrence of plant pests and micro-organisms – plant pathogens –, as well as their destructiveness and life cycles change with the development of technologies and with the changes in climate, therefore studies in entomology and plant pathology are topical and will remain such in the coming decades.

Doctoral theses and dissertations defended after 1990

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2. Priedītis A. (1995). *Integrated apple pest control in Latvia*: scientific summary for acquisition of Habilitated doctor's degree in agronomy (Dr. habil. agr.). Jelgava: LLU. 63 p.
3. Bankina B. (1995). *Occurrence and features of Phialophora cinerescens – causal agent of carnation wilt*: doctoral thesis for the acquisition of scientific degree in biology (Dr. biol.). Rīga: LU. 37 p.
4. Bisnieks M. (2005). *Epidemiology of barley yellow dwarf virus (BYDV)*: doctoral thesis for acquisition of PhD in philosophy.

5. Moročko I. (2005). Characterization of the strawberry pathogen *Gnomonia fragariae*, and biocontrol possibilities. Doctoral thesis for acquisition of PhD in philosophy.
6. Bimšteine G. (2005). *Inventory of Phytophthora infestans population and optimization of the performance of the datorized forecasting models*: summary of the dissertation for the scientific degree Dr. agr. Jelgava: LLU.
7. Apenīte I. (2010). *Biology, ecology and economical importance of the cranberry tipworm Dasineura vacinii in Latvia*: summary of the dissertation for the scientific degree Dr. agr. Jelgava: LLU. 46 p.
8. Grantiņa I. (2012). *Brassica stem and pod weevil* (*Ceutorhynchus* spp.) *and Brassica pod midge* (*Dasineura brassicae*) *biology, ecology and economical importance in Latvia*: summary of the dissertation for the scientific degree Dr. agr. Jelgava: LLU. 47 p.

Scientific books after 1990

1. Turka I., Sigvald R. (1997). *Recommendations for control of cereal and potato pests and diseases. Risk Thresholds.* Jelgava – Uppsala. 31 p.
2. Priedītis A. (1997). *Useful wild animals and their use in plant protection*. Rīga.120 p.
3. Priedītis A. (1999). *Critical thresholds of crop pests for substantiation of biological and chemical protection measures.* Latvia University of Agriculture, Ministry of Agriculture, Latvian Plant Protection Research Centre, Rīga, Jelgava. 16 p.
4. Turka I., Bankina B. (1999). *Recording methods of potato and cereal diseases and pests and introduction of tests in the integrated protection systems*. Jelgava. 41 p.
5. Turka I. (2000). *Pesticides and the Environment*. Latvian Agricultural Advisory and Training Centre. 35 p.
6. Turka I. (2005). Detection of plant health and security risks. *In*: *Risks in agriculture and private forestry.* Ed. P. Rivža. Jelgava, Latvia University of Agriculture, Faculty of Computer Science and Information Technology of Rīga Technical University. p. 118–201.
7. Turka I. (2007). Options and risks of cultivation of genetically modified plants in Latvia. *In*: *Agriculture and food risk management.* Ed. P. Rivža. Jelgava: LLU. p. 186–209.
8. Turka I., Ruža L. (2007). Attitude of rape producers towards options and challenges in the cultivation of genetically modified oilseed rape. *In*: *Agriculture and food risk management.* Ed. P. Rivža. Jelgava: LLU, p. 210–216.
9. Bankina B., Balodis O., Gaile Z. (2010). Advances of fungicide application for winter oilseed rape. *In*: *Fungicides*. Ed. O. Carrise. Vienna: Intech. p. 157–177.
10. Bankina B., Turka I. (2013). *Recording methods of plant diseases and pests*. Jelgava. 24 p.

Research in Plant and Soil Biology

Vilhelmīne Šteinberga, Ina Alsiņa

The Department of microbiology was established at the University of Latvia in spring 1919. Its founder and longtime manager (till autumn 1940) was professor Dr. Augusts Kirhenšteins (1872–1963). In 1923, he created the serological laboratory (serum station) at the University of Latvia, on the basis of which later, in 1946, the Institute of Microbiology of the Latvian Academy of Sciences was founded. As the director, he made a lot of significant studies and discoveries.

A. Kirhenšteins contributed greatly to the advancement of science, particularly in the field of microbiology, virology, and biotechnology. In 1939, when Jelgava Agricultural Academy was established, the Institute of Microbiology started its work in Jelgava – in the newly renovated premises equipped with modern laboratories. In the fall 1940, prof. A. Kirhenšteins left work at the Academy; thus, the study and research work in the disciplines of microbiology changed. Dairy microbiology was taken over by the Dairy Department (head of the Department – docent Dagmāra Talce), and veterinary microbiology – by the Department of Livestock Diseases. Other disciplines of microbiology were handed over to the Department of Microbiology (head of the Department – docent Alfrēds Kalniņš).

Already in 1936, professor A. Kalniņš (1895–1989) initiated research on biological fixation of atmospheric nitrogen, which has evolved as a major topic for scientific research already for three-quarters of a century. In 1937, production of rhizobia bacteria preparation – nitrogen – was started in laboratory conditions. Distribution, virulence, activity, competition ability, and phage effect on the symbiotic properties of clover rhizobia were investigated (A. Kalniņš). Distribution and activity of pea–vetch–bean (Valdis Klāsens (1935–2005)), lucerne (I. Belicka (1937–2012)), and lupine (Jānis Filipovičs) group rhizobia in soils in Latvia were identified. With the appearance of the new crop – galega – in Latvia, studies on establishment of *Rhizobium galegae* into the host plant roots (Vilhelmīne Šteinberga, V. Klāsens) were initiated. Research on the competitive abilities of rhizobia and its establishment in the roots of the host plants, as well as strain efficiency studies were carried out (A. Kalniņš, V. Klāsens, V. Šteinberga, Biruta Mārka, Maiga Niedrīte, Ina Alsiņa). Research also focused on the influence of mineral elements (especially of nitrogen) on the fixation efficiency of nitrogen in field beans (Antons Marnauza), lupines (B. Mārka), and lucerne (I. Alsiņa). In 1973, the collection of the rhizobia strains approved at the Department was included in the International Catalogue of Collections, and the most efficient strains were used in the nitragin production.

In recent years, research on the option of using not only rhizobia, but also mycorrhiza fungi in order to raise the productivity of legumes has been intensified (V. Šteinberga, I. Alsiņa, Laila Dubova, Ligita Liepiņa). Currently, in the collection of the Institute of Soil and Plant Sciences, there are 44 active strains of rhizobia and their molecular inventory is carried out (Andris Bāliņš).

From 1959, under the supervision of docent Milda Krūklande (1909–2002), the academic staff of the Department investigated microbiological activities during the conservation process in silage, and in dried silage and haylage. Dozens of lactic acid bacteria strains have been isolated, their acid production ability has been tested, and manufacturing technology of silage starter – silobacterin – has been developed. The preservation process of cereal grasses, lucerne, clover, and other types of grasses depending on moisture content, enzymes, environmental reaction (pH), temperature, and other factors affecting the microbiological and biochemical changes and the quality of the preserved forage has been studied (M. Krūklande, V. Šteinberga, Juris Priekulis).

In some periods, the scientific interests of the Department addressed a range of issues related to the field of economic development. Thus, already in the 1930s, prof. A. Kalniņš studied microbiological and biochemical processes of flax retting.

Several times at different periods, the scientific interest of the Department was focused on the microbiological decomposition of cellulose in soil. The impact of crop rotation, farming systems, and pre-crop on microbiological ability to cleave cellulose was examined.

At different times and with different methods, microbiological and enzymatic activity of soil was explained. The following issues have been studied: decomposition of green manure and its

effect on soil fertility (A. Kalniņš), soil microflora trend in decomposition of permanent grassland swards (M. Krūklande), and impact of the farming system, crop rotation, pre-crop, and crop on the microbiological and enzymatic activity of the soil (V. Šteinberga, L. Dubova).

Also the influence of certain microorganisms on plant growth and activity has been addressed. Next to other topics, also free-living nitrogen binders have been studied (M. Krūklande – efficiency of azotobacterin; V. Klāsens, L. Dubova, and I. Alsiņa – *Azotobacter* genus; L. Dubova and I. Alsiņa – *Trihoderma* sp.).

Studies on antimicrobial activity of various compounds have been organised in several stages. The scientists took interest in the chemical composition and biological activity of propolis, in tree and shrub bud scales (Silvija Palmbaha), as well as in the influence of the oregano and thyme extracts on the growth of different groups of microorganisms (I. Alsiņa, L. Dubova).

Plant physiology studies are related to the scientific work of Marija Tauja (1889–1975) (before 1936 – Tilmane). M. Tauja was the first female scientist in Latvia; from 1920 to 1959, she conducted research and taught plant physiology at the University of Latvia. From 1925, M. Tauja delivered the plant physiology course also to the students of the Faculty of Agriculture (at that time, the Faculty of Agriculture belonged to the University of Latvia). From autumn 1944, she worked as a docent at the Latvia Academy of Agriculture, and from 1945 to 1949 – as the head of the Department of Plant Physiology.

Plant physiology studies are related to the research of the macrosymbiont. The conducted research explained the formation of the harvest, as well as the changes in biochemical and physiological parameters of legumes caused by rhizobia (V. Klāsens, B. Mārka, I. Alsiņa).

In the middle of the previous century, more attention was paid to maize to explain its growth stages and growing opportunities in Latvia (Helēna Mauriņa), as well as peculiarities of mineral nutrition (B. Mārka).

Constantly, but with different intensity, garden plants have also been studied. The following topics have been addressed: accumulation of vitamin C in vegetables (Genovefa Ruštāne – in the 1950s); solanine and saponin accumulation and their effects on physiological processes in various plants, particularly in potatoes and cucumbers (M. Tauja); and accumulation of physiologically active compounds, as well as stimulation options in vegetables (beginning of this century – I. Alsiņa, L. Dubova).

Some studies have been conducted on the effects of microelements on plant yield formation and quality of the harvest: Romualds Januševskis – on strawberries, and I. Alsiņa – on accumulation of selenium in vegetables.

In the 1950s–1960s, the influence of various pickling preparations on the development of grain germs was researched (R. Januševskis).

The effect of the quantitative and qualitative composition of the light on plant growth and development has been examined. M. Tauja conducted studies on the effect of different light wave lengths on plant transpiration, V. Klāsens explained the influence of spectral composition of light on weed seed germination, and I. Alsiņa researched the impact of the quantitative and qualitative composition of light on the accumulation of physiologically active compounds in vegetables.

In recent years, as required by manufacturers, research on the influence of biological preparations on plant growth and development, yield formation, and microbiological and biochemical parameters of soil has been carried out (I. Alsiņa, L. Dubova)

History of the Horticultural Science

Mintauts Āboliņš

Horticultural science can be divided into four main research directions: fruit production, vegetable production, ornamental gardening, and apiculture.

Fruit production. Important scientific research in fruit production began with the work of professor Jānis Sudrabs – the long-standing Head of the Department of Horticulture (1922–1971). He is the author of many educational and other books on fruit production. He has studied the causes of fruit tree perishing with cold, varieties of cross pollination of fruit trees, suitability of fruit and berry varieties for the conditions of Latvia, as well as opportunities to improve productivity of orchards. Professor J. Sudrabs can be considered to be the scientific founder of fruit production in Latvia.

During this time, at the Department of Horticulture, 19 candidate and two doctoral theses were elaborated. Some of the major theses: Evdokija Taranova (1950) – on apple pollination, Eižens Pētersons (1950) – on viticulture in Latvia, and Hermīne Zilberjāne (1951) – on cherry breeding. The further rapid development of fruit production was promoted by studies on fruit cultivation and its prospects in the various fruit-growing areas in Latvia under the supervision of professor J. Sudrabs.

Together with J. Sudrabs, also other staff members of the Department of Horticulture were actively involved in scientific research. From 1941 to 1944, Kārlis Lapiņš worked as an assistant at the Department. In later years, he became one of the most prominent Latvian exile fruit breeders. He worked in Summerland, the National Horticultural Research Station in Canada. K. Lapiņš, applying physical and chemical mutagens, obtained column-type crown-shaped forms of sweet cherries and apples, as well as for the first time in the world's history, bred self-pollinating varieties of sweet cherries.

The research of Vilis Bausks on the biology of sour cherry, and of Antons Spolītis on flowering and fertilization biology of the variety 'Latvijas dzeltenā olu plūme' is of great importance in the history of fruit cultivation. Assistant professor of the Department of Horticulture Pauls Gailītis (1940–1948) studied grape growing in Latvia and set up a vineyard in Sabile (1936–1939). Jēkabs Karulis (1940–1950) worked on the effects of apple rootstock on the yield of apple varieties. Anatolijs Burmistrovs (1950–1951) studied winter grafting of the plum and use of line spacings in orchards. The long-term lecturer of the Department Gaida Rapa (1968–1991) studied inbreeding of strawberry varieties and the effect of heterosis on strawberries.

At the beginning of the 1990s, one of the main objects of the research carried out under the supervision of professor Imants Gronskis was the local Latvian cranberry (*Vaccinium oxycoccus* L). The advantages of this berry over the American large-fruited cranberries were higher cold tolerance and better quality of the berries. In breeding, physical and chemical mutagenesis was applied in the selection of productive wild clones. In a breeding material farm, 172 cranberry genotypes were studied, the majority of which (altogether 163) were selected in Latvia, but the rest in Estonia and Russia. The cranberry clones generated by means of selection were tested for cultivation in recultivated marshes. Aivars Šņickovskis, Rūta Kronberga, Marta Liepniece, and Biruta Grīnberga worked intensively in this field.

Within the framework of the research carried out at the Department, the following themes were studied: propagation of the best genotypes with wood and softwood cuttings, arrangement of plantings, the advisable plant stocking level, substrates, characteristics of the morphological and biological factors of plants, and other issues.

There was also a task to create the incorporation for space-conditioning of high-quality specimens in the low-production cranberry bogs, as well as to recultivate degraded peatlands with cranberries. Later, studies on the introduced American large-fruited cranberry species, (*Vaccinium macrocarpon* A.) were continued. Owing to the favorable climatic conditions in Latvia and to the large areas of raised bogs, it was possible to cultivate these cranberries in commercial areas. However, there was much uncertainty about the choice of varieties, substrate, fertilization, and other issues.

A number of market-oriented projects on American large-fruited cranberries were implemented under the supervision of assoc. professor Mintauts Āboliņš. Studies were continued in the research project of the Latvia University of Agriculture "Development of horticultural production technology and quality model for the Latvian agro-ecological conditions" (2005), and in the project subsidized by the Ministry of Agriculture in cooperation with the State Institute of Fruit-Growing "Environment-friendly growing technologies in fruit and berry orchards in different soil and climate conditions", sub-topic "Blueberries and cranberries".

Next to the American large-fruited cranberries, also blueberries were explored. Cranberry and blueberry varieties, their physiological condition after the wintering period, the production technology, the nature of the location, yield, and quality were identified. Research was conducted also in the area of propagation of blueberries with softwood cuttings (M. Āboliņš, M. Liepniece, Dace Šterne, Baiba Tikuma, Rudīte Sausserde, Līga Gurtaja).

The experimental results were presented at major international scientific conferences: in Oeiras, Portugal (2004), in Nitra, Slovakia (2007), and in Oregon, USA (2008).

In 2008, the Faculty of Agriculture organized a large international scientific conference on cranberries and other less common fruit.

A significant problem in cultivation of blueberries is cold tolerance of the varieties, therefore further research was directed on the study of the problem in cooperation with the Latvian State Forestry Research Institute "Silava" within the framework of the project of the *Latvian* Council of Science "*Vaccinium spp.* winter hardiness biological aspects". Basing on this research, D. Šterne elaborated her doctoral thesis "Temperature influence on blueberry *(Vaccinium corymbosum* L.*)* winter hardiness and plant productivity".

Another direction in fruit growing was growing of high-quality fruit tree planting stock applying various varieties and rootstock combinations. Research under the supervision of M. Āboliņš and in cooperation with Pūre Horticultural Research Centre was conducted within the framework of the project of the Latvian Council of Science "Development of sustainable fruit and vegetable production systems" (2001–2004).

The apple variety and rootstock compatibility level was investigated applying the auksanography method elaborated at the Department. It allows determining conformity of the daily growth rhythm between the variety and the rootstock. Next to this method, it is possible to determine monthly and weekly rhythms of growth, analyse the inoculation adhesion place, and identify accumulation of starch above and below the grafting. The best combination of inoculation has been established (M. Āboliņš, M. Liepniece).

Studies in collaboration with the National Institute of Fruit Growing have been done on the berry, mostly blackberry, gene pool and its usefulness in breeding. As a result, assistant professor Kaspars Kampuss defended his thesis "Research of black, red and white currant (*Ribes* L.) genetic resources in Latvia".

Under the supervision of assoc. professor M. Āboliņš, two doctoral theses (Ilze Grāvīte "Evaluation of flowering buds and individuality of flower fructification of plums and its influencing factors", and B. Tikuma "Bees and bumble bees role in pollination of large cranberry (*Vaccinium macrocarpon* A.)") are being elaborated at present, and one (Daina Feldmane "The influence of drip irrigation and woodchip mulch on yield formation and fruit quality of young sour cherry (*Prunus cerasus* L.)") was defended in 2012.

Vegetable production. The origins of the vegetable production science cannot be determined precisely and cannot be separated from the common horticulture history in Latvia. Only gradually, for practical purposes, the branch, bringing together researchers, practitioners, and teachers, was formed for addressing issues related to vegetable production.

In the development of vegetable cultivation, a very important role was played by the pioneers of this field who tried to transfer their own knowledge, often acquired abroad, to the Latvian gardeners. Thus, already in 1783, the first book on agriculture was published in Latvian, describing, among other things, cultivation of vegetables. The first book in Latvian about vegetables was written by Jānis Cigra in 1806. From 1860, Latvian horticulturists turned more actively to vegetable growing. The work performed in the middle of 19th century contributed significantly to the advancement of science of vegetable production in Latvia. Latvian gardeners consider specialists and vegetable growing enthusiasts such as Jānis Penģerots–Svešais, P. Gailītis, Pēteris Dindonis, J. Sudrabs, and Paulis Sukatnieks to be the first scientists in the area of vegetable production. Their books were used by agricultural students in their study and research work for decades.

P. Dindonis is the author and co-author of many books, of which the most important is his textbook "Profitable vegetable growing", published several times from the first edition in 1926 till the last edition in 1942. He is also one of the first vegetable breeders. The cucumber variety 'Dindoņa Zaļie ķekari' he bred is still known and maintained.

The specialist in vegetable cultivation P. Gailītis, widely known and highly respected in Latvia, was assistant professor and lecturer in vegetable production at LLU until 1947. He is the author of several books on vegetable growing; the most significant of them are "Cultivation in Greenhouses" (1948), and "Large-scale production of vegetables" (1946).

J. Sudrabs, LLU professor, Doctor, Head of the Department of Horticulture, and fruit-grower, read lectures in vegetable production during the post-war period. In the book "Gardening" (1942), an important place is given to vegetable varieties and breeding.

One of the most topical issues – production of early vegetables – was addressed already in the first years of the post-war period. The research focused on the impact of the vegetable cultivation practices on vegetable ripening. The studies were carried out under the supervision of professor J. Sudrabs at the LLU, resulting in a set of agronomic measures, a novelty for that time – agro-mineral composition of the seedling pots. Under the guidance of Mirdza Baumane, growing of seedlings in peat humus pots was initiated in Latvia; later, technologies for production of early vegetables under Latvian agro-ecological conditions were developed.

In the 1960s, scientific work of the Department was devoted to the issues related to the early and high yield production problems of perennial vegetables not widely spread at that time

(rhubarb, horseradish, sorrel, perennial bulbs) in order to ensure compliance with the production requirements. As the result of tests carried out for more than ten years, practical proposals recognised in the production were put forward, thus allowing increasing the areas of these vegetables. The experimental data managed by M. Baumane was compiled and published: "Horseradish" (1959), "Rhubarb" (1960), and "Perennial Vegetables" (1967).

In the covered areas, the studies were related to a relatively new tomato growing technique – applying the deck or the horizontal method. A number of farms began to grow Dutch hybrids, but many gardeners wondered how this technique could be applied to the local breeds. Consequently, studies were carried out under the supervision of M. Baumane at the LLU Department of Horticulture, whereas extensive production experiments were organised in Preiļi and Rēzekne district. The research work focused on increasing the vegetable productivity and extending the product range. The use of the heterosis effect for increasing the yield production and quality was studied more thoroughly, and the results were presented in the recommendations of the Ministry of Agriculture for the implementation in practice.

In the 1970s, research on the vegetables not widely spread in Latvia, such as leeks, broccoli, Savoy cabbage, Brussels sprouts, and asparagus, was continued. Also in the second half of the 1980s, the Department of Horticulture continued working on the improvement and implementation of technologies for growing vegetables and herbs not widely spread in Latvia (M. Baumane, Kārlis Dzērve, Ieva Žukauska). From 1985 to 1990, much attention was paid to testing of the new vegetable varieties to check their suitability to Latvian agro-ecological and economic conditions.

The research work in vegetable production initiated in the previous periods continued also in 1990. As Latvia became open to the world market, the range of previously less know vegetables expanded rapidly. Therefore, at the beginning of the 1990s, one of the Department's research directions was related to studies of these species with the aim to develop an agronomic set that would ensure the early and total yield, as well as the quality compliant with the European standards, minimising the need for manual work. Supervised by professor M. Baumane and senior lecturer K. Dzērve, in the experimental fields and farms of the Department of Horticulture, trials were arranged to explain properties of the new varieties and hybrids, their suitability for specific growing conditions and objectives in order to select the most appropriate technology for acquisition of high quality production.

In 1997, the Department initiated implementation of the project "Use of local gene pool for conservation and development of vegetable cultivars suitable for Latvian ecological conditions". Within the framework of the project, studies were carried out to identify and restore the gene pool of cucumbers, and to create new parental lines of hybrid production. The research was completed with Līga Lepse's doctoral thesis for acquisition of the Doctoral degree in Agriculture – "Using of morphological criteria and molecular markers in renewing of cucumber variety 'Dindoņa Zaļie ķekari'".

In the mid-1990s, the Department of Horticulture initiated research on development of agronomic techniques for growing herbs in commercial gardens (I. Žukauska). The aim of the research was to develop scientifically sound proposals to reduce the risk factors in most topical technological stages of herb species cultivation. The conclusions reached from the studies were published in international and local conferences, and in professional journals.

An increasingly central role at the international level is taken by identification and evaluation of genetic resources, and by research of factors determining diversity of wild plants, including the most

characteristic plant specimens collected in the wild. With the growing interest in the genetic material of herbs and medicinal plants in Europe, in 2000, an international collaborative project was initiated with the support from the Nordic Gene Bank – "Aromatic and medicinal plants in Nordic and Baltic countries. Strategy for genetic resource conservation". The goal and objectives of this project was the development of *in situ* and *ex situ* strategies for conservation of herbs and aromatic plants, creation or supplementation of collections, characterisation of the collection material according to descriptors developed by project participants, as well as elaboration of a detailed conservation strategy. Within the framework of the collaboration project between the Nordic Gene Bank and the Baltic countries, descriptors for species *Origanum vulgare* L. and *Thymus spp.* L. were developed (I. Žukauska, Irina Sivicka).

Since 2005, the "Programme for conservation and sustainable use of agricultural and food, livestock, forestry and fish genetic resources" of the Ministry of Agriculture has been implemented. Projects on conservation and study of collections of aromatic and medicinal plant genetic resources, and of innovative technologies for producing high-quality, safe and healthy food products from genetically, physiologically and biochemically diverse plant material have been carried out. Evaluation and selection of the genetic diversity of oregano (*Origanum vulgare* L.) and thyme (*Thymu*s ssp. L.) gene pool with subsequent selection depending on the detected physiologically active substances have been organised (I. Žukauska).

The method of molecular markers has been applied more extensively in the studies of genetic resources. The Institute of Agrobiotechnology conducted a project on the research of the Latvian aromatic and medicinal plants, applying the molecular markers (Antra Balode).

Several studies on the effect of physiologically active compounds on vegetable growth and development, and on vegetable enrichment with mineral elements deficit in the Latvian conditions have been completed.

Ornamental gardening. After the World War II, excellent theses were elaborated in ornamental gardening under the supervision of professor J. Sudrabs. A significant problem in the cultivation of roses was the choice of appropriate rootstocks; therefore this topic has been addressed in several scientific works (Jānis Mežsēta, 1946). The following topics were examined under the supervision of professor J. Sudrabs: induction of flowering in lilies of the valley (S. Pīlēģis, 1947), chrysanthemum blooms (Olga Romanovska, 1948), tulips and their prospects in Latvia (Milda Vilmane, 1960), summer flower seed growing (Velta Zvirgzdiņa, 1959), decorative properties of roses (Dzidra Rieksta, 1958), etc.

From 1950 to 1970, studies were related to the development of a plan for parks and greenery. This work was continued by Ernests Otmanis, who later became the senior lecturer at the Department of Horticulture. Under his supervision, various themes on ornamental plants were elaborated: azalea, cyclamen, carnation, calla, gladioli; resistance to diseases of varieties of roses; use of annual flowers; ornamental plant propagation techniques; and early induction of flowering in lilacs, hyacinths, daffodils, and lilies of the valley. The widely known floriculturist and breeder of perennials Valdemārs Nesaule worked in the teaching and research farm in Jelgava, where he set up extensive plantings of perennials in the 1950s.

Supervised by professor I. Gronskis, several studies were carried out on growing and propagation of ornamental trees and bushes *Actinidia* and *Schisandra chinensis*, as well as on other themes related to ornamental plants.

From 1968, assistant Valdis Ozols took active part in the scientific research, focusing on rose rootstocks and varieties. He is the co-author of the book "Roses" (1983). Studies in ornamental gardening from 1970–1980 were led by assistant R. Kronberga and senior lecturer K. Dzērve.

Since the early 1990s, Aija Dižgalve has been working in the field of ornamental gardening. Different types of research projects have been carried out on the mixed growing system, as well as on the assessment of its suitability for the planting stock of ornamental trees. A number of Bachelor's and Master's theses have been developed on the results of the research on increase in grafting of ornamental trees and shrubs.

Within the framework of the project of the Scientific Council of Latvia "Factors determining engrafting of coniferous trees and investigation of grafting growth", a research was carried out on the factors affecting grafting of coniferous trees (2009–2012), using "Dimzas" as the research farm. The inoculation trend in the newest species of conifers – *Abies, Larix, Picea,* and *Pinus* – was examined and evaluated. In the research, the best methods and the optimal timing for grafting under greenhouse and field conditions were identified: quality criteria for the planting material of the grafted plants were developed (A. Balode, A. Dižgalve, R. Sausserde).

During the time period from 2006 to 2010, the following market-oriented projects have been implemented at the Horticulture and Apiology Study and Research base of the Institute of Agrobiotechnology of the Faculty of Agriculture: "Aquatic plants propagation system research and development of cultivation technology" (A. Dižgalve), and "Research on production and marketing of ornamental plants in Latvia" (M. Liepniece).

Senior researcher, Dr. agr. A. Balode continued research on lilies, and the research results were presented in her doctoral thesis defended at the Faculty of Agriculture – "Estimation of the initial material and some methods applied in lily breeding" (2002). Within the framework of the market-oriented research project, new and efficient lily reproduction methods have been developed (2005–2006). Patents have been received – "Method for propagation of lilies" (patent No. 14110 B), and "Method for reducing grey mold infection of lilies" (patent No. 14301 B); a patent application has been submitted – "Invention of improving lilium seed germination" (No. P-12-178) (A. Balode). The State Plant Protection Service has made a decision to grant the breeder's right for 30 varieties of lilies (applicant – Latvia University of Agriculture; breeder – A. Balode).

To conserve biodiversity, research has been carried to assess the population of the Latvian *Lilium martagon* and its use in selection. A number of natural sources have been examined, comparing specimens and collecting seeds. To limit the gray mold (*Botrytis cinerea*) in lilies, studies with microbiological agents – trichodermin and vitamins – have been carried out. Flowering time of different groups of lilies has been evaluated in trials.

A research has been initiated on introduction and acclimatization of the lily species, carrying out the hybrid resistance test, inventory of the local genetic material, and investigation of various propagation methods (generative – with seeds; vegetative – bulbs, cuttings, and meristem culture *in vitro*).

The study results have been presented at international conferences in San Remo, Italy (2006), Bangkok, Thailand (2007), Lise, the Netherlands (2008), Antalya, Turkey (2009), Leiden, the Netherlands (2009), Lisbon, Portugal (2010), Pescia, Italy (2010), and Bisley, UK (2011), as well as at local conferences at the Latvia University of Agriculture, Jelgava (2012).

Currently, Diāna Meiere is elaborating her doctoral thesis "Truffle research and introduction network for farmer start-ups and universities" within the framework of the Latvian–Lithuanian cross-border cooperation programme (scientific advisor A. Balode).

At the Horticulture and Apiology Study and Research base of the Institute of Agrobiotechnology of the Faculty of Agriculture and at the Research and Study farm "Vecauce", woody plants with underground mushroom *Tuber aestivum* mycorrhiza have been planted. The natural diversity is researched in Latvia (Zemgale, Kurzeme, and Latgale) and Lithuania (Klaipeda, Siauliai, and Kaunas counties) in order to search for underground mushroom fields.

Apiculture. In the early 1920s, the Latvian apiculture industry was fragmented – small apiaries, various types of hives, different methods applied; therefore the honey harvest varied greatly – from a few kg to 60 kg per one colony.

In the 1930s, professor Pēteris Rizga started his research in apiculture. He was one of the founders of the apiculture science in Latvia. He studied the history of apiculture, beekeeping organisation, profitability of apiaries, quality of honey, wax extraction, production of artificial cell, bee breeding, and queen rearing technology. Prof. P. Rizga also set up a collection of nectar plants and an apiculture museum in Vecauce, and studied bee diseases and their combating options. Besides, P. Rizga developed new types of hives – fixed hives and transportable hives required for different methods of beekeeping; constructed and launched production of heather honey extractor; and defended his doctoral thesis on travelling apiculture.

Students took active participation in the scientific work and elaborated their theses in beekeeping. Marta Bembers participated in the research under P. Rizga's supervision. The directions of her research were queen rearing techniques and methods that would be suitable for propagation in the conditions prevalent in Latvia. Later, M. Bembere worked as the manager of the wax processing workshop in Vecauce training farm (1934–1944); after the World War II, she supervised the students' field work in Rāmava training farm.

In the 1950s–1960s, lecturer in apiculture E. Otmanis created apiaries in the study farms of the Latvia University of Agriculture (LLU). In the 1970s–1980s, research on restriction of varroasis was conducted under V. Ozols' supervision. Lecturer in apiculture R. Kronberga (1980–1989) researched the increase in productivity of bee colonies in Latvian apiaries.

In the 1990s, Armands Krauze initiated research on the conservation, exploration and breeding of the population of the Latvian local honey bees (*Apis mellifera melifera*) as a part of the Latvian fauna (2000–2012).

The Latvian local honey bee is distinguished by its very good cold resistance in the Latvian climatic conditions; however, such undesirable characteristics as expressive aggression and excessive swarming tendency together with the raising of the disease resistance and productivity of honey should be corrected in the breeding process.

It has to be noted that the local honey bee has long been in close contact with other varieties introduced. Therefore, in the apiary of LLU, not only conservation but also restoration of the given material is carried out. Consequently, the selection process is organized basing on the morphology and instrumental insemination of queen bees. The Horticulture and Apiology Study and Research base of the Institute of Agrobiotechnology of the Faculty of Agriculture is the only place in Latvia that deals with research and breeding of the Latvian local honey bee, applying instrumental insemination of queen bees.

Work on the honey bee breeding development in the country has been commenced in cooperation with the Latvian Apiculture Society. Systems worked out in the apiary are used as the basis for the honey bee breeding development. For example, honey bee breeding programme includes documentation, bee rating systems, systems of morphological analysis, etc. It should be noted that honey bee breeding has not been carried out in Latvia before; therefore the entire system was built from scratch (Valters Brusbārdis).

Research on the spread and control of varroasis in Latvian apiaries has been conducted in cooperation with the Latvian Apiculture Society. In collaboration with the Information Technology Department of LLU, studies on the wintering of bees are carried out in wintering bee hives under controlled conditions (temperature – 5 °C, and humidity – 60–65%).

History of the Livestock Farming Science

Daina Jonkus, Daina Kairiša, Ziedonis Grīslis, Jānis Latvietis, Jāzeps Sprūžs

The history of the livestock farming in Latvia is closely related to the origins of agricultural education at the Agricultural section of the Rīga Polytechnicum, where studies and research in general livestock farming started already in 1868. Persivals Štegmans was one of the first professors who began to lecture general livestock farming.

The first practical study in livestock nutrition was made at the State and Research farm "Pētermuiža" already in 1877. In 1895, Jelgava Farmers' Association organised an exhibition of agriculture, crafts and industry, where for the first time not only in Latvia but also in Czarist Russia the Gerber method for determining the fat content in milk was demonstrated. Determining the milk fat content on the site in this exhibition, it was established that the Angeln (Angler) cattle, imported in Latvia with the objective to improve local cows, gave milk with a low fat content. This was an important discovery for the agricultural management of that time, as great attention was paid to promoting the butter production. The solution was found later: the Angeln cattle were replaced with another improved breed – Danish Red cattle, which had already reached a higher milk fat content.

The option to accurately, relatively inexpensively and easily control the cow milk fat content facilitated expansion of the individual cow productivity control or the so called monitoring work. In 1902, supervisory societies were founded. Farmers joined in associations; hired control assistants (supervisors), who controlled individual animal productivity in the assigned farms by applying a common methodology; and introduced the "barn book" and the "book of annual accounts", which calculated the productivity of each cow during the reference year. The monitoring work led to productivity increase in the controlled cows. From 1912 to 1939, the milk yield increased from 2096 kg to 2896 kg, and the milk fat content – from 3.81% to 3.93%. The monitoring process contributed to the increase in the economic profit of cow keeping. The success can be explained not only by selection, but also by improvement of the forage base. Farms began to enrich pastures, extend clover and root crops, to grow protein-rich crops for animal feed, and to feed cows with oil cake.

With participation of cattle monitoring associations in forming of new breed crossings, by crossing the local cattle with the Danish Red breed, the Latvian Brown cattle breed was created and approved in 1922. Breed cultivation was carried out also in other animal species. The Latvian Warm-Blooded horse and the Latvian Darkhead sheep breeds were approved in 1937.

During the first period of Latvia's independence, scientific activities in the field of livestock farming were concentrated mainly at the Faculty of Agriculture of the University of Latvia, and from 1939 – at Jelgava Academy of Agriculture. Study and research farms of the University of Latvia and of the Jelgava Academy of Agriculture, "Vecauce" and "Rāmava", were used as the research base. Science and higher education were closely linked; therefore, the academic staff members conducted a number of studies in several livestock farming sectors: A. Bušmanis un Paulis Lejiņš – in horse breeding and dairy farming; Fridrihs Neilands – in dairy farming; Arvīds Silmalis – in pig farming; P. Rizga – in apiculture and poultry farming; and A. Kirhenšteins – in dairy bacteriology.

After the World War II, studies in livestock farming were directed to solve practical problems related to the war-affected economy, including restoration of livestock farming, extension of cow, pig, sheep and horse herds, arrangement of breeding activities, development of the forage base, raising of healthy animals, and providing proper nutrition for animals.

The first scientific research institutes were established in February 1946. The research centres for studies in livestock farming and veterinary medicine were the Institute for Zootechnics and Zoohygiene, and the Faculties of Agriculture and Veterinary Medicine of the Latvia Academy of Agriculture. The majority of scientists, including the directors of the Institute professors P. Lejiņš and Jānis Bērziņš, worked both at the Academy and at the Institute.

Professor P. Lejiņš, though being occupied with the responsibilities of the president of the Academy of Sciences, did research on the environmental impact on the development of livestock exterior and productivity of dairy cattle, and on the effect of different foods on animal productivity. Besides, prof. P. Lejiņš was engaged in the breeding of cows and horses raised in Latvia, and in creation of a stable forage base.

P. Rizga can be considered as the founder of modern apiculture in Latvia. Besides the extensive research and publications in beekeeping and poultry farming, he successfully trained the new apiculture and poultry farming specialists, who later, in their turn, became the teachers of today's beekeeping specialists. After 1950, the work of professor P. Rizga in solving apicultural problems was taken over by Kira Balode (Institute for Zootechnics and Zoohygiene), and in poultry farming – by Paulīna Grosmane (Institute for Zootechnics and Zoohygiene) and Jānis Rozenbahs (Latvia University of Agriculture).

In the early 1950s, A. Silmalis together with Kārlis Brencis conducted research on pig farming, care and rational nutrition.

Professor J. Bērziņš when living in Russia researched the use of freshwater lime and wood ash in livestock nutrition. Having returned to Latvia, he continued the already started researches, as well as commenced research into biological significance of microelements (cobalt, copper salts, etc.) in livestock nutrition, which was a completely new research direction in Latvia at that time. For these studies, in 1964, J. Bērziņš and academician Jānis Peive won the Lenin Prize, which was the highest government award of that time.

Andrejs Valdmanis, owing to his untiring work capacity and high-level cognitive ability, grew from a research assistant to a director of a laboratory, to academician of the Academy of Sciences, and became the leading scientist in the former USSR in the field of vitaminology, gaining recognition also from his foreign colleagues.

J. Bērziņš, attracting lecturers Jānis Būcis, Ilga Laiviņa, Fjodors Garkāvijs and others from the Latvia University of Agriculture (LLU), studied beef and dairy productivity, and influence of heifer keeping conditions on their development and subsequent productivity.

The great research interest of Boļeslavs Sivčiks was cattle craniological types, which he studied at Moscow Timiryazev Agricultural Academy and also later – after moving to Latvia in 1951. B. Sivčiks studied the characteristics of bone formation of the Latvian Brown cows depending on the type of keeping and feeding conditions, and addressed these topics also in the theses of his postgraduate students.

P. Grosmane, before moving to Latvia, had carried out her scientific work at the All-Union Scientific Research and Technological Institute of Poultry; after prof. P. Rizga's retirement in 1950, P. Grosmane took over the management of the Department of Poultry Farming of the Institute for Zootechnics and Zoohygiene. Her research focused on the relationship between the external traits (exterior) and productivity of hens, on the influence of fowl keeping conditions and nutrition on their development, and on the commercial cross breeding in poultry farming. Besides, P. Grosmane educated recognized scientists, her successors Elga Klieste, Erna Ozola, Margarita Līkopa, Ira Vītiņa, Vera Krastiņa, Aina Erte, Jānis Nudiens, and others.

Scientific activity of Georgs Ūdris was largely related to studies of prof. J. Bērziņš, who was also his scientific advisor. G. Ūdris' studies on the role of cobalt, manganese, zinc, copper and iodine salts on cow nutrition, and on the effect of microelements on metabolism and animal resistance were concluded with elaboration of two theses – for acquiring the degree of the candidate of sciences in agriculture, and afterwards – the doctoral degree in agricultural sciences. Later, G. Ūdris established successful research collaboration with Jānis Neilands, which resulted in two monographs on the biological role of zinc and molybdenum in animal metabolism processes.

A. Popovs carried out research on raising the efficiency in young cattle fattening; the research results were published in Russian and Latvian.

The foresight of the management of the LLU Departments and of the directors of the Institute for Zootechnics and Zoohygiene (since 1963 – the State Research Institute of Animal Husbandry and Veterinary Science) is noteworthy, as they carried out very successful and intensive enrollment and training of the new scientists. From 1955, within less than a 10-year period, more than 30 young scientists have been trained and educated in postgraduate studies in livestock farming. These names speak for themselves: A. Ozols, I. Pētersone, Rūta Lukstiņa, J. Neilands, Jānis Pinkulis, Fjodors Garkāvijs, Jānis Latvietis, Ilma Ramane, Pēteris Ošļevskis, Antons Rekšņa, Gunārs Brēmers, Reimārs Kaugers, E. Klieste, Modris Kreilis, Andrejs Cālītis, Uldis Osītis, V. Krastiņa, Lūcija Rācene, Arvīds Segliņš, Miervaldis Pastuhovs, Jānis Vētra, Ausma Dzenīte, Emīlija Meijere, Raimonds Baltakmens, Aleksandrs Jemeļjanovs, and others. Later they became the leading scientists in their scientific subsectors.

The period from 1950 to 1960 in Latvia was associated with radical changes in agriculture. The establishment and consolidation of collective farms, as well as establishment of larger farms created the need for new organizational forms in livestock farming.

The new situation called for relevant research and solutions to improve the technologies for keeping and feeding livestock. To be able to gain a foothold in the USSR animal breeding market, the following themes appeared in the scientific research schedule of the Latvia University of Agriculture and of the Institute for Zootechnics and Zoohygiene: productive and genetic improvement of Latvian Brown breed cows (Grigorijs Akimovs, J. Būcis, B. Sivčiks, Ligija Cjukša, Ilga Ezera); perfection of the udder placement and shape and of the milking characteristics for adaptation to mechanized cows milking (F. Garkāvijs, M. Kreilis, I. Laiviņa);

improvement of the fattening properties and fertility of the Latvian white breed pigs (K. Brencis, Uldis Ramanis, Agnese Zommere, R. Kaugers and others).

Regarding selection of the Latvian Darkhead sheep, it was directed towards improvement of wool quality and clip, as well as towards increase in sheep liveweight and fertility (M. Katlaps, L. Cjukša, Jekaterina Volgajeva, Laima Spalviņa).

At that time in poultry farming, issues related to multiple formation of poultry flocks, to lighting and keeping mode, as well as to vitamin supply in the new conditions for different species of poultry became topical. These issues were addressed in the research works of P. Grosmane, E. Klieste, E. Ozola, M. Līkopa, and others.

Previous studies of the Latvian scientists (J. Bērziņš, A. Valdmanis, A. Lācis, G. Ūdris, M. Līkopa, Jēkabs Riba) had already identified the most suitable feeding norms of macro- and microelements, vitamins and amino acids for different species of animals under conditions of Latvia. They formed the basis of combined forage enrichment with the above-mentioned biologically active substances. Latvia became the pioneer in the entire USSR in preparing, producing and feeding such a rich fodder. For the results of these studies, the Latvian scientists received 12 medals, of which three were gold medals.

During this period, research on unconventional forage type – silage and haylage – was started and rapidly expanded. The following scientists worked on this issue: J. Pinkulis, I. Ramane, Vitolds Liberts, K. Brants, Egīls Ramiņš, and later also Valdis Auziņš, Artis Kalējs, and others. Science-based recommendations were elaborated for preparation of silage and haylage in concrete trenches, surface ricks, sealed towers, with and without preservatives for preservation of damp grain and for preparation of combined fodder for pigs and poultry. It was not the time of bales and synthetic films yet; however, Latvia's experience in the preparation of silage and haylage was recognised and presented in different all-union conferences, seminars, and exhibitions.

The scientists, on the basis of the research results, tried to encourage the livestock specialists to use feed and work rationally. Here the following studies must be noted: raising calves with reduced doses of whole milk, and use of whole milk and skimmed-milk substitutes for feeding calves and other young animals (J. Bērziņš and R. Lukstiņa); introduction of "shedding" days and restricted feeding in raising of fattening pigs, young cattle, young poultry, and fur-bearing animals (J. Latvietis, E. Zariņa, E. Ramiņš, J. Riba, E. Klieste, U. Ramanis); introduction of new forms of work organisation in dairy farming and pig-breeding; and double milking of cows (V. Zariņš, K. Gūtmanis, A. Rekšņa, M. Kreilis, F. Garkāvijs).

In the 1970s, a new direction appeared in agriculture and livestock farming: specialisation and industrialisation of manufacturing. Livestock farming measures were formed differently from the previous work Technologies. They had to be synchronised with monitoring and maintenance of forage production and animal feeding, raising and veterinary conditions. The research plans of LLU and State Research Institute of Animal Husbandry and Veterinary Science covered issues related to the development of animal keeping and feeding technologies; to the identification of zootechnical and zoohygienic parameters in the dwelling places of dairy cows, fattening cattle, fattening and breeding pigs, laying hens and broiler chickens for the production of livestock products applying industrial production methods; and to the reconstruction of the largest farms for ensuring production at a new quality.

In the result of foreign experience and research initiative of the local scientists, new forage resources emerged: grass juice, grass paste, grass pomace, grass flour, and cuttings. The research on

their production, conservation, use and evaluation took place within the framework of the complex topics "Transformation of Photosynthesis Products" and "Microbiology and Biotechnology in Fodder Production" under the supervision of academician Mārtiņš Beķeris. The research involved also LLU scientists J. Latvietis and Andris Miezītis.

The LLU academic staff (Pauls Andersons, Jāzeps Sprūžs, J. Latvietis, Skaidra Zaharčenko, J. Riba, and others), in their turn, carried out research on the use of biologically active substance antioxidant diludine, growth promoter fenibut, and a variety of antibiotics and other substances in animal nutrition, as well as on their biological and zootechnical effect. For these studies and for introduction of the preparations into production, the scientists were awarded two State Prizes.

To ensure a balanced nutrition for animals in the conditions of manufacturing technologies, the LLU Animal Nutrition Department elaborated regulations for animal nutrition control and for optimisation of feed intake applying an increased number of criteria, as well as recommendations for the use of these regulations to optimise the ration of cows, pigs, sheep and horses with the help of electronic computing machines (J. Latvietis, Lūcija Kārkla, Jānis Ozols, Ārija Pauka, A. Ratkeviča, and others). Also the best options were studied for optimum feed intake structure and consistency in cow nutrition in mechanised large farm complexes, for example, cattle nutrition in mechanised farms, and cattle nutrition with uniform compound feed (U. Osītis, L. Kārkla, A. Slēze, and others).

Leonīda Aboma, I. Laiviņa, Antoņina Seņņikova, I. Ezera, Alfrēds Seržāns, L. Cjukša, and other specialists initiated arrangement of a special shed for first calvers at the Research and Study Farm "Vecauce"; there first calf heifers were milked, as well as milk production, udder characteristics, and the exterior and other indicators were measured.

With the introduction of industrial technologies in livestock farming, in order to rapidly increase the productivity of cows, the specialised dairy cows already widely recognised in the world were brought in: Holstein-Friesian Black-and-White and Red varieties, Ayrshire, and Swedish Red-and-White. Extensive research was organised (Didžus Strautmanis, F. Garkāvijs, L. Cjukša, E. Zariņa, Albīne Tabūne, Vitālijs Kižlo, Māra Jansone, and others) for comparing the crossbreeds in Latvia's conditions; the study results were used for elaborating the breeding policies and breeding plans in Latvia.

Similar comparing work of breeds and their crosses was carried out also to improve the meat qualities of Latvian Brown cows and to solve issues related to increase in beef production by using industrial crossbreeding of the Latvian Brown and imported beef cattle breeds, as well as by organising the production of beef on the basis of imported beef cattle. For meat production needs, Hereford, Aberdeen Angus, Charolais, and Limousine sires were imported. In these studies, J. Latvietis, Aina Holma, Ivars Rūvalds, and V. Jaunzems actively participated.

Breeding work in pig production was directed towards improvement of fast growth, fattening performance, and meat quality, using pure breeding and formation of new genetic lines (A. Veģe, A. Stira, R. Kaugers, Ziedone Bērziņa, Helēna Zivtiņa, etc).

Research on conservation of the genetic potential of Latvian Darkhead sheep and on improvement of their meat and wool qualities using males of a few imported breeds was carried out by L. Spalviņa, L. Cjukša, L. Volgajeva, and Genovefa Norvele.

Light (sport) horses started to dominate in the breeding population of horses, and also the horses' valuation principles and methods changed. In 1981–1990, I. Norvelis, R. Baltakmens, Pēteris Stikāns, A. Seržāns, Guntis Rozītis, and other equestrian enthusiasts and scholars developed the

Latvian horse breed selection and evaluation system, as well as the breeding plan for this breed of sport horses.

Poultry keeping in multi-level battery cages in the conditions of manufacturing technologies, in dwelling places not in contact with the external environment and without natural light created urgent problems that had to be solved in order ensure not only the health of the birds but also high level of productivity and economically efficient production of eggs and poultry meat. Scientists organised a range of research on the following subjects: control, comparison and evaluation of productivity and other economic properties of birds of different crosses (M. Līkopa, J. Nudiens, E. Erte, Aina Dēliņa). identification of optimal lighting arrangements for birds of various ages (J. Nudiens); improvement of egg incubation performance (I. Vītiņa, E. Erte, Marija Vucēne); and use of various protein and calcium sources and biologically active substances in poultry nutrition (E. Ozola, M. Līkopa, I. Vītiņa, V. Krastiņa, and others).

With changes in production facilities and in organisation of livestock farms, new requirements for breeding organisation were put forward. Such turning-point was the use of computing technology; its origins were laid in 1964 when the Analytical Breeding Station was created under the supervision of the Cattle Farming Section of the State Research Institute of Animal Husbandry and Veterinary Science. Its foundation was initiated by A. Cālītis in 1965. Later, the breeding data processing system SELEKS was established, and it became a model for the use of electronic computing systems in the breeding work not only in the USSR but also in a number of other socialistic countries. Scientists of the LLU (F. Garkāvijs, Ziedonis Grislis, M. Jansone, A. Veģe, Vladimirs Stašs), in their turn, elaborated an evaluation and breeding information system data bank.

After Latvia regained independence in the early 1990s, there were radical reforms introduced in the agricultural production process, which significantly affected the development of the livestock farming science. Collective farms and state farms were abolished, but part of the livestock – slaughtered. In the new conditions, the situation in livestock farming had to be clarified and the measures for further action had to be developed; therefore, the livestock farming scientists focused on livestock surveying and on preserving and developing the animal gene pool.

In cattle farming, the research initiated in the late 1980s on the improvement of the productivity of dairy cows was continued. Under the supervision of professor F. Garkāvijs, studies on the relationship between the cow exterior and their productivity were conducted. Prof. F. Garkāvijs was the advisor to doctoral student Ivans Vorslovs, who defended his doctoral thesis “Linear evaluation of the Black-and-White and Latvian Brown cow exterior parameters in Latvia” in 1990. Professor L. Cjukša together with her doctoral students researched cattle pre-natal and post-natal treatment and keeping of calves with their mother during the prophylactic period. Under her leadership, Ainārs Nābels-Šneiders developed his doctoral thesis “Improvement of the technology for raising calved cows and heifers in dairy farming establishments”, and defended it in 1992.

Extensive studies were carried out in livestock nutrition. Animal scientists J. Latvietis, J. Sprūžs, Lilija Degola, I. Vītiņa, V. Krastiņa, A. Erte and R. Kaugers were enrolled in the development of fodder supplements for pigs, goats, calves, and hens. Anita Baumane developed her thesis “New combined fermentation additives in the nutrition of agriculture animals”, which she successfully defended in 1996. Seven biologically active food supplements, which became the nutrition components in animal feed production plants, were included in the Forage Register of the Republic of Latvia (D. Grīnhofa, J. Latvietis, J. Nudiens, J. Sprūžs, and others).

Fodder conservation theory was expanded taking into account the new knowledge and recommendations for forage preparation from wilted silage mass and from early maize varieties using preservatives, thus helping to address issues of preparation of high quality forage in farms (I. Ramane, Dace Kravale, V. Auziņš, A. Runce, and others).

Research started on the development of the evaluation systems for energy and protein in feed materials in the Baltic countries, adapting them to those used in Europe (U. Osītis).

In order to determine sire evaluation models most suitable for the conditions in Latvian, research of linear statistical models was launched in the early 1990s. It was important to identify the factors influencing cow productivity and the factors with largest share of impact to be included in the model used for analysis. The use of linear statistical models for sire genetic evaluation applying the Animal model of the Best Linear Unbiased Prediction method was completed with Līga Paura's doctoral thesis "Elaboration of the model for the bulls' genetic evaluation appropriate for Latvia's conditions" in 1999 (advisor Ziedonis Grīslis).

This period was very fruitful for establishing and strengthening contacts with the universities and research institutions of Europe and the USA. The international cooperation within TEMPUS and other international programs should be emphasised, as within the framework of these projects many researchers, students of master and doctoral studies participated in exchange and internship programs at the University of Wales in UK, at the Swedish Agricultural University in Uppsala, at the Christian Albrechts University in Kiel, and at the University of Hohenheim in Germany. Together with the university researchers and colleagues from Estonia and Lithuania, international conferences and seminars on cattle, pig and poultry breeding and nutrition and on animal production quality problems were organised annually.

In the next period, after the year 1999, the progress of scientific activities in the field of livestock farming was ensured in line with the priority research directions approved by the Latvia Academy of Agricultural and Forestry Sciences. Implementation of the research project "Perfection of Latvian cultivated productive animals and poultry breeds through internationally approved breeding methods" was divided into 11 sub-themes, which were developed by such researchers as J. Nudiens, J. Sprūžs, D. Strautmanis, V. Jaunzems, V. Kižlo, A. Holma, Z. Grīslis, L. Paura, Daina Kairiša, Daina Jonkus, A. Veģe, M. Jansone, Z. Bērziņa, G. Rozītis, G. Norvele, J. Volgajeva, A. Jemeļjanovs, V. Krastiņa, I. Vītiņa, and others.

In the research on the possibilities for obtaining organic livestock production, the content of heavy metals in the samples of feed, animal products (milk, meat, eggs), and animal hair was determined (Jānis Mičulis, Silvija Strikauska, J. Latvietis, I. Rūvalds, Aiga Trūpa).

Much attention was paid to research of balanced nutrition of the livestock. Additives and premixes were developed on the basis of the local raw materials, which were the equivalent of similar feed additives produced abroad. From these studies under the supervision of scientific advisor J. Latvietis, two doctoral theses were elaborated: L. Degola – "Development of new mineral premixes and their biological evaluation considering the status of mineral substances in local feedstuffs", A. Trūpa – "Comparison of mineral additives produced in Latvia and abroad in the feeding of dairy cows"; both theses were defended in 2001.

Trials on silage quality were also continued. In 2004, Baiba Ošmane defended her doctoral thesis "Regularities of the vegetation stage effect on ensilage capacity and feeding value of forage grasses grown in Latvia" (advisor I. Ramane), and Maija Beča – "The changes in protein and amino acid content in different grasses silage during preparing" (advisor J. Sprūžs).

For pork quality improvement, research on Latvian White pigs and on F1 crossbreed pigs was carried out, and the quality of the crossbreed and purebred pig carcasses was evaluated for a period of several years (E. Ramiņš, R. Kaugers, A. Stira, Ausma Veģe, Z. Bērziņa).

Studies were carried out on the morphological composition of chicken eggs of the Lohman Brown and Hisex Brown crossings. Nutrition experiments were organised to search for substitutes of antibiotics to raise the efficiency of broiler chicken meat production.

The specialised beef cattle farming developed. Industrial crossing of low productive dairy cows with beef bulls increased rapidly (V. Jaunzems, I. Rūvalds).

After accession to the European Union in 2004, the issues of production of high-value crops and animal products, conservation of livestock genetic resources, as well as research of key productivity traits became very topical.

A significant and economically important research direction was focused on the individual cow milk productivity indicators and on the development of the scientific justification of the production of high-quality lamb meat. The research results were summarised in D. Kairiša's doctoral thesis "Scientific justification of good quality lamb meat production in Latvia" (advisor J. Sprūžs), which was defended in 2005, and in D. Jonkus' doctoral thesis "Analysis of the cow milk productivity traits variation", which was defended in 2007 (advisor L. Paura).

To successfully research the genetic resources of livestock, it was essential to launch studies in the molecular genetics. An important event for the Faculty of Agriculture was the opening of the Molecular Genetics Research Laboratory in December 2006. The Laboratory was basically intended as a livestock genetic resources research centre. The research was carried out by Z. Grīslis, D. Jonkus, L. Paura, D. Kairiša, and G. Rozītis. The first working period was devoted to the acquisition of the animal origin and paternity testing methods. The next working period included studies of milk protein gene genetic polymorphism in Latvian bred cattle populations, which in 2008 were initiated by L. Paura and D. Jonkus, and from 2009, within the framework of the project of the Latvian Council of Science No. 09.1461 (2009–2012) "Biotechnology methods used for evaluation of milk protein gene genetic polymorphism in Latvian bred cattle populations and impact of protein genes on the productivity of the cows", were continued by the Head of the Molecular Genetics Research Laboratory Dace Smiltiņa and scientist Z. Grīslis.

The question still topical was acquisition of a precise livestock genetic evaluation, where the choice of the correct model and method is of great significance. The evaluation of BLUP animal model used in Europe and in the world for evaluating sires was replaced by BLUP random regression test-day animal model. Therefore, the further linear model application studies in breeding evaluation in Latvia were associated with the application of "test-day model" data. This work was completed with Rita Zutere's (Sarma) doctoral thesis "Scientific justification of parameters for early breeding value estimation methods of dairy sires and cows" (advisor Z. Grīslis; defended in 2008).

The scientific basis for production of high quality, unpolluted, safe and healthy food of animal origin was developed at the Scientific Institute of Biotechnology and Veterinary Medicine "Sigra" within the framework of the research project "Clean and nutritious food: quality criteria and competitiveness" (project manager A. Jemeļjanovs). In 2010, Imants Jansons defended his doctoral thesis "Impact of feed additives of plant and organic acid origin on productivity of pigs and on the quality of meat" (advisors J. Nudiens and A. Jemeļjanovs). In order to diversify the raw materials used in food production, researchers of "Sigra" started to use such non-traditional animal and bird species as ostriches, pheasants, quail, deer, and others.

Scientists and doctoral students of the Institute of Agrobiotechnology of the Faculty of Agriculture (D. Jonkus, Diāna Ruska, Kristīne Piliena, D. Kairiša, Indra Eihvalde, L. Paura, D. Smiltiņa, Dace Bārzdiņa, L. Degola, A. Trūpa, Elita Aplociņa, G. Rozītis, Iveta Kļaviņa, Laine Orbidāne, and others) continued their researches on the improvement of economically useful characteristics of the Latvian bred livestock species, keeping them purebred and for interbreeding using the cow, sheep and horse breeds popular in Europe, as well as pig hybrids and poultry crossings. The studies are focused on meeting the requirements for the welfare of farm animals both in organic and conventional farming systems.

The Beginnings of Latvian Plant Protection Research Centre and Its Activities Over a Century

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Latvian Plant Protection Research Centre

Abstract. The article provides an overview of the research directions and activities in plant protection carried out in Latvian Plant Protection Centre (LPPRC) over a century. On February 4, 1913, the Ministry of Agriculture ratified the statutes of the Association of Baltic Pest Control Station of Agricultural Crops; this date can be regarded as actual birthday of plant protection as the field of research in Latvia and in the whole Baltic Region. Despite different changes in legal status and name, the mission of the institution – identification of diseases and pests or weeds that cause problems to the development of crop plants, finding solutions for their control, testing of the new plant protection products, and, eventually, disseminate the information accumulated among agriculturists of Latvia – has remained unchanged over 100 years of its existence. Research topics have replaced one another, but they have always built on actual problems in agriculture and on the basis of knowledge already accumulated by the scientific community of the world. Since 1914, many projects have been implemented in collaboration with well-known producers of plant protection products in the world on the efficiency of their products under Latvian agro-climatic conditions. LPPRC has an important role in agriculture and in the local and international domain of science, which will be strengthened also in the future.
Key words: LPPRC, LSCPP, pests, diseases, weeds, plant protection products.

February 4, 2013, marked 100 years since the first organization for research in the field of plant protection has been established in the Baltic Region. Its foundation was closely linked with modernization of agriculture in Latvia in the second half of the 19th century, when new varieties of field crops were brought in from Europe and when farmers started to apply different fertilising products, e.g. lime, marl, gypsum and ash, more readily, as well as tried out some novel soil cultivation techniques using a more up-to-date agricultural machinery.

In this period, the crop farmers seeking to strengthen their farms in order to reduce their dependence upon the landed gentry started to found societies. The first Latvian agricultural society was established in Plāņi parish, Valka region, in 1866.

To expand their freedom of action, already the first congresses of agriculturists in 1871, 1873, and 1899 passed decisions on establishment of the union of farmers' societies; however, this was fiercely opposed and blocked by landlords who feared that "*the intended central farmers' union could grow into a political force capable of jeopardising the power of the landed gentry in Latvia*" (Savienība „Latvijas ..., 1931). Due to this, the Central Union of Riga Agriculture (RLC) came into existence only on 24 July 1906, thus becoming the first alliance of farmers'societies not only in Latvia but also in entire Russia, the part of which Latvia was at that time. The ultimate goal of RLC was "*enhancement and modernization of Agriculture in Latvia with joint forces of agricultural societies*" (Savienība "Latvijas ..., 1931).

Alongside with intensification of farming, the inevitable problems of pest and disease control of the crops emerged creating a logical need for agricultural research. Therefore, H. Celmiņš, agronomist, in an RLC meeting in front of a larger audience, for the first time raised the issue of an entomological research station. The meeting passed a decision to assign the RLC Board in coordination with the Agriculture Department with the task of completing all the preparatory work required for the foundation of the above-mentioned station including selection of an appropriate site for research trials (e.g., Priekuļi Manor). In 1911, RLC started vigorous preparations for the foundation of the entomological research station. Jānis Bickis, lecturer of Priekuļi agricultural school, was nominated Head of the research station. His contribution to the foundation of the first plant protection research institution in Latvia and the whole Baltic Region is inestimable.

Eventually, after a period of targeted preliminary activities, which included both education extension trips of J. Bickis to Kiev and St. Petersburg and drafting of the foundation documents, on February 4, 1913, the Ministry of Agriculture ratified Articles of the Association of Baltic Pest Control Station of Agricultural Crops (the term "pests" was attributed to all organisms harmful to crops – both insects and diseases). This date can be regarded as actual birthday of plant protection as the field of research in Latvia and in the whole Baltic Region. The articles of association defined the main assignments of the research station:

1) detailed research of the crop pests of both plant and animal origin;
2) scientific and practical development of controlling methods thereof;
3) assisting the communities in the Baltic Region in pest control through all-round dissemination of knowledge on the existing pests and their control.

Despite the fact that the research station was not yet fully operational in 1913, its main action lines were already outlined. There was a high interest among the farmers on different damage patterns caused by pests and diseases in their crop fields, therefore the station received a large number of samples sent in by farmers. Thus, in 1913, three turnip samples were received from Allaži parish, where the station had detected the cause of damage as fungi *Plasmodiophora brassicae* Wor., and recommended liming and crop rotation as the preferred ways of its control; in rye samples from the same parish, the cause of yellowing identified was frit fly *Oscinis frit*; and in samples of apple tree branches from Vaiņode parish – apple canker was identified (Rīgas Lauksaimniecības ..., 1914). Thus, the research station had commenced identification of the harmful organisms, followed by recommendations of the plant protection measures required for their control.

The station pioneered also summarization of the information on incidence of separate harmful organisms by use of surveys among farmers, horticulturists, and foresters. In 1913, data from 35 survey forms were summarised (altogether 300 forms were sent out). Supplementing the data obtained with personal observations, in the annual report of 1913, J. Bickis had enumerated pests and other harmful organisms of the following plant species: 9 – of field crops; 11 – of fruits and vegetables; 3 – of forest crops, 14 disease causal agents – of field crops; 14 disease causal agents – of fruits and vegetables, and 2 disease causal agents of mushrooms; almost all of them are listed among important harmful organisms up to this day.

On 10 November, 1913, the RLC meeting passed a decision on replacing the name of the station with Baltic Bio-Entomological Station.

In 1914, entomologist V. Rodzjanko became the staff member of the station who was involved in the research of forest pests; also several resident students were involved including Maksis Eglītis, student of Agricultural Department of the Riga Polytechnic Institute, who later became an outstanding researcher of plant diseases and a professor, was elected Dean of Agricultural Department of the Latvia University of Agriculture, later – Head of the Chair of Plant Diseases (1939–1944), and, finally, Rector of the Latvia University of Agriculture (1944).

Already on the second year of operation of the Station, trial plots were set up to carry out targeted research studies on different pests and diseases, their controlling and eradication methods. For instance, J. Bickis was engaged in a number of studies on control of the striped flee beetle (*Phyllotreta*) in turnip fields, where he discovered that *Phyllotreta* damage can be largely prevented by late sowing; on the importance of copper sulphate in treatment of winter wheat, discovering that increase in the concentration of copper sulphate reduced grain germination power, while the minimum killing dose for smut spores was 2% solution of copper sulphate, etc. (Savienība „Latvijas ..., 1931).

In 1914, the first order was placed by a producer of chemical products to test the applicability of its products for pest and disease control. "Kosmoss", the soap and chemicals factory, wanted to test the suitability of lime sulphur infusion for combating the pests and diseases widespread in gardening.

In 1914, the station embarked upon yet another activity – taking part in agricultural exhibitions (Vestiena, Valka, and Valmiera), where it demonstrated herbariums of diseases, collections of pests, and other visual aids. Written handout materials on separate diseases and pests were also prepared. In 1914, the brochure on eight pages "Apple Blossom Weevil" by J. Bickis was issued in 4 000 copies, and a much more substantial and thorough material (24 pages) – "Bunts of Grain Crops and other Cereals" – was published in 1915 (Rīgas Lauksaimniecības ..., 1915).

A crucial prerequisite for development of the research station as seen by J. Bickis was building its research on the basis of knowledge already accumulated by the scientific community of the world. Therefore, since as early as 1914, purposeful efforts were invested in collection of research literature and in formation of a scientific library. At the very end of 1913, a letter came from Imperial Bureau of Entomology, London, Great Britain, requesting the station to send them by post on regular basis all published materials, reports and articles for their reprinting in journal "The Review of Applied Entomology". The letter was accompanied by a set of copies of the journal of 1913 and a promise to send it to them henceforth regularly (as the matter or fact, copies of "The Review of Applied Entomology" issued at the beginning of the last century are still found in the library today). The Bureau of Mycology and Phytopathology in St Petersburg also undertook to provide the station with copies of its scientific journal. The funds of the library were regularly supplemented by annual reports of similar research institutions (e.g., Besarabia Province Entomology Station in Kishinyev) and by purchasing books directly from publishers in Riga (Входящчие бумаги, 1914–1917). It should be noted that still today the Latvia Plant Protection Centre research library funds contain publications entered in 1913–1914.

At the start of the 20th century, practicing of different plant protection measures in crop fields, plantations and fruit gardens was an absolute novelty, and the Baltic Bio-Entomology Station was the only institution the mission of which was finding reasons for plant damages and proposing solutions to remedy them. Therefore it was assigned with organization of purchase of the chemicals' spreading machinery and making this type of machinery available to farmers.

For example, in 1914, Baltiņi Dairy Society (Madona) turned to the station requesting delivery of a sprayer, and Farming Society "Sakne" of Sēlpils had ordered a sprayer and chemicals for treatment of berry bushes (Входящчие бумаги, 1914–1917).

After the vigorous start-up described above, the World War I imposed hindrances on the activities of the station. In 1915–1916, scientists still managed to continue some research in Estonia Province, in regions of the North Vidzeme, in Priekuļi, and in Bulduri Horticulture School; however, in 1917–1919, a total crisis set in, following a partial destruction of the inventory and documents of the station. However, in this period, still some studies were carried out on application of different chemicals for disease control of the crop plants. Resident student Kārlis Colks tested the suitability of fungicides for the control of powdery gooseberry mildew *Sphaerotheca mors-uvae* and established that good results could be achieved applying green soap with washing soda as well as the lime of sulphur infusion. M. Eglītis found out that disinfection of soil with formalin could efficiently prevent the club root disease of cruciferous plants *Plasmodiophora brassicae*. J. Bickis, in his turn had tested the efficiency of spraying potatoes with Bordeaux solution as an efficient method of control the potato blight (Savienība „Latvijas, 1931), which *inter alia* still today finds itself among the registered plant protection products in Latvia.

In spring of 1919, the station revived and restarted its research work. Kārlis Starcs, who in later years distinguished himself as a well-known botanist and weed researcher, was involved as assistant to the Head of the Station. Also Edgars Ozols, later a prominent entomologist and the Agriculture Department professor (1926–1928, and 1944–1967), was enrolled. He engaged himself in research of the *Hymenoptera* order of the plant pests. Together with J. Bickis, he carried out in-depth research of biology, ecology, and controlling measures of Japanese silver fire sucker, establishing that satisfactory results could be achieved by use of kerosene emulsion and infusion of *Quassia amara* tree chips. Jānis Zirnītis, graduate of Bulduri Horticulture School, became staff member of the station in 1921 and later specialized in entomology. Already within his first year at the station, he performed observations in different parts of Latvia and wrote surveys on incidence of the pests in crop fields and plantations (Savienība „Latvijas ..., 1931).

It should be noted that from the very start of its existence, the Station was closely involved in the education of the young agronomists. Since 1920, alongside with his duties as the Head of the Station, J. Bickis worked as Head of the Plant Pathology Chair of Latvia University of Agriculture. In 1920, the Station started collaboration with the Faculty of Agriculture of the Latvia University of Agriculture – its 2nd year students covered a two-week entomology practice (Head teacher E. Ozols) and phytopathology practice (Head teacher J. Bickis) (Savienība „Latvijas ..., 1931).

In 1922, major staffing changes took place at the Station. J. Bickis, the long-standing Head of this research institution, left his post to fully dedicate his efforts to education of the young agricultural experts at the Latvia University of Agriculture and Priekuļi Agricultural School. Agronomist Maksis Eglītis was instituted to this post as the result of the decision passed on May 13, 1922, by Board of Central Union of Latvian Agriculture (LLC). Jūlijs Smarods, mycologist and phytopathologist, was appointed his assistant, who would spend all of his professional career in this research institution, engaged in important studies of parasitic and saprophytic fungi and eventually collecting the largest standard fungi herbarium "Latvian Fungi" ("*Fungi latvici exsiccati*", 1931–1956, which consisted of 1350 specimens) (Smarods, 1963).

As the Station had always regarded the information of the general public on harmful organisms and on their control methods as an assignment of maximum importance, on June 1, 1922, the LLC

headquarters were transferred to 4a Baznīcas iela inRiga, a house which was the property of the Station. An up-to-date research laboratory was also set up there and equipped with a thermostat, autoclave, microtome, binocular microscope, and other implements, fixing up premises for the studies of the pest development cycles in laboratory conditions, as well as a camera for multiplication of the fungi disease agents. At the same time, the department conducting almost all field trials remained in Priekuļi. Since 1923, the Priekuļi Department was headed by entomologist Jānis Zirnītis, the future professor of the Academy of Agriculture (1945–1947, and 1951– 1960).

With expansion of the scope and role of the Station, a decision was taken by LLC in 1923 to rename it Plant Protection Institute. The importance of the research institution considerably grew. The Department of Weeds and Flowering Plants was established, headed by Kārlis Starcs. For successful research and advising of farmers, the Institute established regional departments in different parts of Latvia (in 1923, in Malnava, headed by Jānis Ozers), Kaucminde (headed by agronomist Jānis Vīksna), Head Forestry of Piltene; while in 1924, new departments were set up in State Cīrava Forestry School (arboriculturist Hugo Upīts), in 1925 – State Stende Breeding Station (headed by Emīls Bērziņš).

In 1924, the range of services delivered to farmers by the Institute expanded even wider. Thus extending also the functions performed by this institution. In autumn, at Priekuļi Department, the Treatment Post for treatment of crop seeds with chemical products and hot water was opened. Researchers performed inspections in seed production farms, as well as inspected potatoes intended for export at the request of the Ministry of Agriculture.

The opening of Plant Protection Museum under the auspices of the Institute on 26 February, 1926, in Riga should be noted as an exceptionally outstanding event. Its main purpose was education extension through providing answers to farmers and other interested parties on the causes of damages incurred by plants and their diseases, as well as controlling measures thereof.

The time period from 1923 to 1929 was extremely rich in activities as the ongoing research studies had a vast thematic scope. All in all, regarding the results of research carried out at the Institute as well as summarising the results of surveys, the list was made identifying commercially the most important harmful organisms in agriculture of Latvia over the 30s of the last century, the further research of which was indispensable: bunts and smuts of grain crops (*Ustilago, Tilletia*), stem rust (*Puccinia graminis*), crown rust of oats (*P. coronifera*), root rot of flax (*Phoma exigua* var. *linicola*), potato blight (*Phytophthora infestans*), snow mould of grain crops (*Fusarium*), apple scab (*Venturia inaequalis*), wireworms (*Agriote s*sp.), the mustard leaf beetle (*Phaedon cochleariae*), flea beetle (*Phyllotreta nemorum*), the codling moth (*Cydia pomonella*), carrot psyllid (*Trioza viridula*), aphids (*Aphididae*), as well as all weeds.

Under the guidance of J. Smarods, studies were carried out on parasitic fungi flora in Latvia, and observations were made on rust resistance of the grain crops and fungi diseases harmful to crops. The research results on grain crop diseases and their controlling methods were summarised by J. Smarods in the manual "Diseases of Grain Crops and their Control" (Smarods, 1924).

Under the guidance of M. Eglītis, research was performed on efficiency of different treatment products against bunt of the grain crops, their impact on the rye root system development, the potential efficiency in respect of the snow mould control, effectiveness of treatment for the flax seeds, as well as research of parasite fungi. The key-book of plant diseases caused by parasitic fungi compiled by M. Eglītis should be singled out as an important achievement of the above research work (Eglītis, 1928). M. Eglītis has also published his research findings of another thematic line:

potato diseases, resistance of different potato varieties against the potato blight and common scab, as well as the importance of Bordeaux and Burgundy solutions in control of the potato blight.

K. Starcs conducted research on weed flora found in Latvia and tested the efficiency of different chemicals in weed control indicating, for instance, the 3.5% sulphuric acid solution as an efficient means of weed control.

E. Ozols addressed the issues of harmful insects (e.g. ichneumon wasp *Ichneumonidae*), conducted research on the more widespread crop pests, was engaged in testing different chemical products for the pest controlling purposes (e.g. use of hydrocyanic acid for fumigation, and the role of calcium arsenate in controlling the mustard leaf beetle), established that lead arsenate 1% solution in water is effective against strawberry leaf beetle *Galerucella tenella*, etc.

P. Zirnītis probed into multi-faceted research of pest development, its impacting factors as well as controlling methods thereof, e.g. studies of the species gout fly *Chlorops taeniopus,* pea leaf weevil *Sitona lineatus,* mustard leaf beetle *Phaedon cochleariae,* aphids, incl. those found on species of *Ribe* family. He clarified the impact of different fertilisers on noxiousness of the carrot rust fly *Psylla rosae* and carrot psyllid *Trioza viridula*, the role of sowing depth on the stage of damage caused by wireworms to barley and oats *Agriote s*sp., the efficiency of different chemicals on aphids, etc. (Savienība „Latvijas ..., 1931).

In 1929, as the result of another managerial staff shift, M. Eglītis was replaced by his former assistant, entomologist E. Ozols to the post of director of the Station. M. Eglītis became a professor at the University of Latvia.

The beginning of the decade of 1930 was marked with several outstanding events for the Plant Protection Institute. It was conferred a national status in 1930, when, pursuant to the Board decision, the institution was renamed Plant Protection Institute of Latvia. Writings of Latvia Plant Protection Institute – *Acta institutide fensionis plantarum Latviensis* – started to be issued, and there were two editions: in 1930 – I, and in 1932 – II. Information on the research conducted at the Institute appeared in referenced editions "Review of Applied Entomology" and "Review of Applied Mycology". The Institute took up international cooperation with scientists from abroad. Writing his fundamental research work and studying microflora, mycologist J. Smarods collaborated with Dr. Gustav Moesz from Hungary. The researchers took part also in drafting of different plant protection regulatory enactments, e.g. "Provisions of exporting and importing potatoes", "Law on eradicating barberries and buckthorns" (1930), and "Plant Protection Law" (1931).

Practical activities of plant protection through advising of farmers and answering their questions occupied a large part of the Institute's working life. Thus, in 1931, 10 clients per day on the average asked for a piece of advice, brought in samples of damaged plants or even the harmful organisms themselves. This resulted to testing of about 2600 samples per year! Both easy to read publications and manuals were written for information of the farming community. A comprehensive volume was prepared, rich in practical information: "Control of pests, diseases and weeds of the cultivated plants". The book had four publications: in 1931, 1933, 1937, and 1943. It was co-authored by M. Eglītis, H. Eglīte, E. Ozols, J. Smarods, K. Starcs and J. Zirnītis, with A. Ķirulis and P. Pētersons contributing to separate publications. The textbook provided information on more than 25 harmful organisms found in sowings and plantations of the cultivated crops, their control methods, the most widespread weeds, their eradication, as well as including a list of plant protection products with descriptions of their application (Kultūraugu kaitēkļu ..., 1931, 1933, 1937).

The year 1933 brought historical changes causing an important impact on the future operations of the Institute. For concentration of the activities of the Institute, the LLC Board took a decision on purchase of a land parcel in Riga for the purposes of the trial plots and building of a laboratory (with a hot house attached). Therefore, on February 14, 1933, the Board turned to Riga City Municipality requesting allotment of about a 0.5-ha large land parcel. The Municipality obliged by allocating about 3300 m^2 of land at Lielvārde street in hereditary lease. In 1934, the construction of the Latvia Plant Protection Institute laboratory was completed. Through purchase of the adjacent parcel of land, the trial plot area was also successfully enlarged to 4773.5 m^2. In spring of 1935, the laboratory moved from Baznīcas street to the new premises; subsequently the department in Priekuļi was closed too.

The event of historical consequence in the life of the Institute was adoption of the Law "On Chamber of Agriculture of Latvia (LLK)" adopted on 1 April 1935. On December 20, 1935, the general meeting of LLC took a decision on self-dismissal and transfer of all its property to LLK; therefore, since 1936, the Institute worked under the auspices of LLK. The Executive Council of LKK adopted a decision on May 12, 1936, to move the central headquarters of LLK to Jelgava, the renovated Viesturs Commemoration Manor. On June 26 of the same year, the Cabinet passed a historical decision to move to Jelgava the Agricultural Faculty of the University of Latvia and turn it into an independent higher education institution under the name of Academy of Agriculture, locating it in premises from which LLK had shortly moved out. On May 3, 1937, a solemn ceremony was held at the Jelgava Castle, welcoming the arrival of LLK Executive Council members, which was a fundamental milestone for a new and important period for agriculture of Latvia. In 1937, in Viesturs Commemoration Manor, the Jelgava bureau of the Latvia Plant Protection Institute was opened.

The end of the decade of 1930 passed in serious research activities, the researchers of the Institute vigorously working in all three locations, serving farmers and advising them on plant protection: Head of the Institute, entomologist E. Ozols, his assistant, botanist K. Starcs, and T. Čakstiņa, entomologist working in Jelgava bureau, J. Smarods, mycologist, conducted research at 4a Baznīcas iela in Riga, while mycologists and agronomists Herta Eglīte and Velta Kalniņa, entomologist J. Zirnītis and intermittently also the Head E. Ozols worked in the laboratory at Lielvārde street.

In the 1930s, the scope of the research was extensive. H. Eglīte tested efficiency of several new treatment products for combating snow mould (*Fusarium*) in rye fields, common bunt (*Tilletia tritici*) in wheat fields, common bunt (*Ustilago hordei*) in barley fields, loose smut (*U. avenae*) in oats, heart rot (*Phoma betae*) in beet plantations, black scab (*Rhizoctonia solani*) and powdery scab (*Spongospora subterranea*) in potato plantations, as well as treated flax seed and peas and checked the efficiency of fungicides for control of the potato blight (*P. infestans*) and berry rust (*Puccinia ribesii-caricis*).

J. Zirnītis studied ecology and controlling measures of currant shoot borer, autumn departure time and ecology of small winter moth, aphid fauna in potato plantations, as well as carried out ecological studies on turnip sawfly and on the efficiency of different chemical compounds on pest restriction (e.g. the effectiveness of glue belts for catching of the small winter moth, the suitability of coal tar on eggs of the fruit tree pests, the impact of different products on carrot psyllid *Trioza viridula*). Studying aphids J. Zirnītis discovered a new species of pests on roots of the perennial grasses *Festuca* and *Poa*, which was named *Anoecia zirnitsi* Mordv. (belonging to the family of

Aphididae). J. Zirnītis carried out also extensive research on incidence, controlling methods, and ecology of strawberry nematode (*Aphelenchoides fragariae*), which is found both in wild and cultivated strawberries, as well as started to look into incidence, development, and controlling methods of European shothole borer (*Xyleborus dispar*).

E. Ozols investigated the decisive climatic factors for the development of mustard leaf beetle and the large striped flea beetle, biology and combating measures of the pea moth, prevalence and development biology in Latvia of the clover pear-shaped weevil (*Apion seniculum*), as well as parasitic insects on larvae of *Apion seniculum*, conducted research on chemical control of the European red mite and Chrysanthemum foliar nematode (*Aphelenchoides ritzemabosi*).

K. Starcs worked together with researchers of the Priekuļi Breeding Station testing the efficiency of sulphuric acid and sulphuric iron solutions in different concentrations on weed restriction in flax plantations, as well as conducted in-depth studies of different weed species.

J. Smarods continued research he had pursued all his working life, namely studies of parasitic microflora characteristic of Latvia.

A. Ķirulis carried out research on parasitic microflora restricting insects. The newly discovered species *Isaria farinosa*, which, according to the research results, contains codling moths and *Entomophthora sphaerosperma*, controlling the cabbage white, should be especially pointed out.

Oskars Jons, the long-standing volunteer researcher of the Institute, dedicated remarkable efforts to research of the order of Tryps (*Thysanoptera*); his collection of thryps was later included in the collection of Systematic Zoology at the University of Latvia (O. Jons died in 1935).

M. Eglītis, acting as an advisor, conducted research in Priekuļi department of the institute, looking for new ways of controlling common bunt, as well as studied the prevalence of rusts in crop fields in relation to the fertilisers applied (Latvijas Lauksaimniecības ..., 1932, 1933, 1934; Latvijas Augu ..., 1937, 1938, 1939). The scientific achievement of M. Eglītis when he acquired the Doctor's degree from the Technical University of Zurich subsequent to defending his doctoral thesis "The impact of infection induced by Bacillus phytophthorus on the temperature and the release of carbon dioxide of potatoes" (*"Der Einflußder Infection auf die Temperatur und die Kohlensäure-abgabe bei Kartoffeln"*) (Eglītis, 1933) was an event of paramount importance for the whole Institute.

The year 1940, another milestone in the history of Latvia, marked also the end of two important periods in the history of the first Latvian plant protection institution: 1) establishment and a successful start-up of the research conducted on site of the Priekuļi Manor (up to June 1, 1922); 2) extensive and productive research in service of farmers and agriculturists of the independent Latvia in Riga and Jelgava, with expanding network of regional affiliations in different provinces and regions of the country (up to June 22 of 1940).

The year 1940 and the following years of the World War II bringing a sharp turn in the life of our nation impaired also the research work of the Plant Protection Institute. Its scope was very much narrowed. In 1944, entomologist J. Zirnītis left for the Academy of Agriculture, while the Institute involved botanist Alfreds Rasiņš, who largely took over the research avenues previously pursued by K. Starcs and dedicated all his professional life to studies of weeds in the Institute. In 1944, when Jelgava Palace was bombarded down, the Jelgava Bureau of the Institute ceased to exist. The war thinned out also the ranks of scientists, as, at the end of 1944, Maksis Eglītis with his wife Herta, who was also a scientist, as well as Karlis Starcs emigrated to the West.

After the war, up to 1948, the Plant Protection Institute still preserved both its old name and research lines and principles; the research work continued, scientific publications were still issued.

E. Ozols continued to be part of the Institute, however for two years being replaced in the post of director by Jānis Pelsis, J. Smarods, V. Kalniņa, and A. Rasiņš. Biruta Lineberga (from 1946 – Rasiņa), and Marta Tauriņa, the subsequent long-lasting assistant of A. Rasiņš, started research work in Institute in 1945. Irēne Liepa was enrolled in 1946.

November 13, 1948, became a crucial point in the life of the Institute, when it was incorporated in the system of the All-Union Research Institute (VAAZPI) and was renamed VAAZPI Baltic Plant Protection Station. Its funding became larger, it was channelled from Moscow, and the staffing was considerably increased. The Station enrolled several young university graduates, mostly from Academy of Agriculture and from Faculty of Biology of the University of Latvia; most of them later in the 1960s completed their post-graduate studies and became well-known in the former Soviet Union with their research and publications: Ilga Žerbele, Maiga Mičene, Rasma Lauva, Rufina Mihejeva (nee Timirjazeva LA), etc. In 1948, E. Ozols was reinstituted as director and headed the Station up to 1960 combining these duties with the tasks of a lecturer at the Academy of Agriculture of Latvia.

In this period, an extensive research was carried out at the Station and its results were published in several magazines popular among students of agronomy sciences and farmers.

E. Ozols indulged in in-depth studies of the insect fauna, especially the family of ichneumon wasps *Ichneumonidae* found both in Latvia and in other Republics of the Soviet Union. Besides, E. Ozols tested different chemical plant protection products for pest control, for instance, established the efficiency of DDT and hexachlorcyclohexan for the control of pea moth (*Laspeyresia nigricana*), the efficiency of DDT for eradication of *Agriotes* larvae, and the impact of hexachlorcyclohexan on frit fly (*Oscinella*) in cereal plantations. The results of his researches were summarised in the book "Entomology of Agriculture" (Ozols, 1948, 1963, 1973).

M. Davidenko carried out studies on the efficiency of hexachlorane for pest control in *Taraxacum koksaghyz* plantations, as well as on the prevalence and development of pests in the flax and sugar beet plantations.

Irēna Kazāka conducted research on the development biology and ecology of the gall midge (*Contarinia medicaginis*), tested the efficiency of DDT and hexachlorcyclohexan on the control of clover pear-shaped weevil (*Apion apricans*), as well as developed a plant protection system for protection of sugar beets against pests.

B. Rasiņa's research interest was prevalence of scale in orchards and berry bush plantations (Rasiņa, 1955), efficiency of DDT and hexachlorcyclohexan on strawberry pests (*Tarsonemus fragariae, Galerucella tenella,* and *Athonomus rubi*), as well as efficient methods of the potato nematode control. Edīte Razauska-Vainovska and Visvaldis Ozoliņš carried out research in entomology.

V. Kalniņa studied prevalence of seed clover diseases, oat resistance to crown rust (*P. coronata*) depending on the plant cultivation practices applied, efficiency of treatments for restriction of snow mould in winter crops, control of loose smut in barley, impact of treatments on seed germination power, and ways of protecting flax plantations against most widespread diseases. Working with different crop seeds and detecting their infection level with fungi disease agents, V. Kalniņa accumulated vast expertise in phytopathological testing of seeds, which later was summarised in a textbook (Kalniņa, Seržāne, 1959).

J. Smarods took over the microflora collection work, prepared five volumes (23–27) of the standard herbarium "Fungi of Latvia" (posthumously, in 1963, the volume 28 was collected and

formalized by mycologists Ilga Žerbele and Edgars Vimba), summarised and systematized the results of microflora studies, and prepared publications (Smarods, 1952, 1953a, 1953b, 1954, 1955a, 1955b). In 1950, J. Smarods started to work on a complex theme of disease dynamics, forecasting options of the course of disease and controlling methods in areas under different crop plants (grain crops, peas, beans, clover, alfalfa, lupine, timothy, rye grass, flax, hemp, sugar beets, potatoes, cabbage, cucumbers, raspberries, strawberries, etc.). At the same time, J. Smarods carried out testing of different chemicals for disease control in areas under grain crops, cabbage, tomatoes, carrots, cherries, and other cultivated plants.

R. Mihejeva worked on testing of different fungicides for the potato blight control, and studied cucumber diseases and ways how to restrict them.

I. Žerbele was engaged in disease prevalence, biological characteristics, and ways of disease control in raspberry plantations.

A. Rasiņš conducted research on the higher plant flora, composition of weed species, and their prevalence in Latvia. He studied biological characteristics of different weed species (e.g. dodder flax (*Cuscuta epilinium*) and pale persicaria (*Polygonum linicola*)), dynamics of weeds in crop rotation of Williams grass fields, as well as efficiency of different herbicides (e.g. 2,4 D, 2M-4X) for weed control, and developed weed restriction systems in the sugar beet, flax and vegetable areas.

Different crop cultivation trials were conducted at the Station. A. Tomsons and M. Mičene were engaged in trials on restriction of oat crown rust by applying different sowing times and using different fertilisation products, as well as testing the susceptibility of different oat varieties to oat crown rust.

V. Gurskis worked on crop cultivation and on chemical methods for successful corn cultivation.

At the end of the 1950s, close attention was paid to projection options of prevalence and development of different harmful organisms in crop fields and plantations, therefore efforts were taken to develop methods for forecast of the most important diseases and pests. M. Mičene headed research on the development of methods for forecast the potato blight.

In the 1950s, a number of publications of research results were prepared; the most important were: “Combating of diseases, pests and weeds of the agricultural crop plants” (Ozols, Rasiņš, Smarods, 1950), “Warehouse pests and their control” (Ozols, Tauriņš, 1951), “Weeds of the crop field and their control” (Rasiņš, 1947), and “Weed fruits and seeds in Latvian SSR” (Rasiņš, 1954).

In 1959, the Station was moved to more spacious premises: a larger two-story building was commissioned at Lielvārde street 36/38. In 1960, K. Davidenko was appointed director of the station.

As from 25 April 1964, the Station was reorganized into the Baltic Affiliation of VAAZPI. At that time, the thematic scope of research was expanded once more: fungi caused diseases of different crop plants, entomology, biomethods, weed control, and toxicology. The research personnel were regularly supplemented with new scientists. University graduates were enrolled both from the Academy of Agriculture and from higher education institutions of other Republics of the Soviet Union.

In 1960, under the guidance of R. Mihejeva, the glasshouse trials were started and prevalence and development of different cucumber root rots were investigated; activities were started on the development of the forecast system for potato blight, as well as on the development of the protection systems of feed crops and sugar beets. Trials were initiated on disease prevalence and development of feed beans, and the role of crop rotations in cultivation of grain crops and pulses in order to prevent infection of plants with the most widespread diseases was investigated.

L. Gavare carried out research on pests and diseases in sugar beet. A. Zemīte worked on the species composition of the wheat common bunt and checked the efficiency of treatments for control it. B. Juhņēviča studied composition of the brown rust dew of wheat.

V. Kalniņa carried out extensive trials in corn diseases and pests, building up a control system thereof.

V. Ozoliņš studied parasites of different plant and vegetable pests, including the beet fly, to use the parasitic organisms for biological control of pests; he also researched the efficiency of entobacterin-3 in pest restriction of vegetables and fruit.

R. Lauva and I. Šutele studied biology and development of the harmful wire worms and frit flies, as well as their control methods in corn fields; and grain crop resistance against pest damage and the efficiency of crop cultivation measures for enhancement of such resistance against frit fly.

I. Šutele conducted research on pests prevalent in seed clover fields and areas under feed beans. Already in 1960, R. Lauva with colleagues started to study biology of pests of the crop that today is the most important one: rape and turnip rape.

M. Mičene conducted a massive long-term research targeted at development and enhancement of the potato blight forecast and controlling system. M. Svikle studied the life cycle and development biology of Colorado beetle. M. Vilka examined vectors of potato virus diseases.

In the middle of the 1960s, A. Zemīte commenced research on the ways of preventing development of diseases in greenhouse, including the efficiency of fumigation.

R. Cinītis performed extensive research on the composition of local entomophages and on the opportunities of their application in biological control of pests, including parasitic organisms of the Colorado beetle and forest pests, investigated ways for prevention of the parasitic organisms for restriction of the pea moth, tested the efficiency of entobacterin in pest control of fruit-bearing plants and cabbage, as well as developed the plant protection system for pest control in cabbage plantations. M. Vilka looked into suitability of trichogrammes for restriction of cabbage pests.

A high contribution to the disease research of the fruit-bearing trees was paid by researcher I. Žerbele, who studied species composition, biology and control methods of the raspberry diseases. Another research line pursued by her was the major disease of cherry trees caused by fungi *Cylindrosporium hiemalis*, and development of its forecast model. She put a lot of effort in studies of the apple tree scab and of the efficiency of fungicides for its prevention. B. Juhņēviča worked with the strawberry diseases and developed their controlling methods. I. Liepa was engaged in the studies of fruit leaf weevil and developed its restriction system.

Noteworthy research studies were carried out in the 1960s by B. Rasiņa, who addressed potato nematodes and tested the efficiency of nematocides for control of these harmful organisms. E. Razauska addressed the problem of potato rot nematode, the characteristics of its development, and invasion.

An important role in the thematic scope of research pursued by the Station was occupied by research of viruses. V. Dūda studied virus diseases of fruit-bearing plants, buckwheat, and vegetables. In the first part of the 1960s, a close attention was paid to prevalence of virus diseases in potato plantations, where research was conducted by V. Dūda. Research was carried out on system development for acquisition of a virus-free planting material, as well as on testing the breeding material for resistance against M and X viruses. E. Vidnere researched the role of weeds as vectors of potato virus diseases.

In the 1960s, extensive studies were carried out at the Station on biology and control methods of weeds. A. Rasiņš was engaged in research of the weed population composition in areas under crop plants, on restriction methods thereof, as well as developed a precise recording methodology of weeds in sown and planted areas. V. Gurskis carried out extensive studies on the population composition of weeds and their control methods in corn plantations. K. Davidenko developed a system for weed control in sugar beet plantations.

In the 1970s, research groups were set up for complex investigation of biology, ecology, projection and control measures of harmful organisms endangering the most important crop plants: diseases of cereals, corn and beets (nostrificated doctor R. Mihejeva, L. Gavare, nostrificated doctor A. Zemīte) and pests (V. Ozoliņš, R. Lauva); potato diseases (M. Mičene, O. Gross, candidate of science L. Davidčika) and pests (M. Svikle); vegetable diseases (A. Zemīte) and pests (nostrificated doctor E. Vainovska, R. Cinītis, S. Skaldere); diseases of the fruit-bearing plants (nostrificated doctors I. Žerbele, M. Eihe and V. Ivanova) and pests (M. Birzgale, nostrificated doctor. B. Rasiņa, E. Vainovska, I. Liepa); nematodes (B. Rasiņa, Ē. Ērenfelde) and weeds (nostrificated doctors A. Rasiņš and V. Gurskis, M. Tauriņa, A. Auns, nostrificated doctor V. Tumans); prevalence and control in planted and sown areas of different crop plants; plant immunity factors (nostrificated doctors J. Rapoports, O. Treikale, and L. Guzeva), etc.

The options of using bio-preparations for the disease and pest control of cultivated plants were actively explored both by treating seeds and by tilling the planted and sown areas. Bio-preparations and their combinations with chemical plant protection products were tested in field crop areas and in the fruit and vegetable areas. Products containing antibiotics were tested intermittently with products containing live organisms, e.g. green lacewing was tested for suitability of pest control.

Huge efforts were made for development of the complex protection systems of the crop plants, setting up prevalence and development projection systems for harmful organisms, combining different crop cultivation patterns and studying the resistance of cultivars and the application of potential plant protection products.

At the same time, work was going on in researching the population structures of harmful organisms and identifying the emerging or increasingly hazardous organisms and characteristics of their development.

All research groups carried out vast-scale trials testing new plant protection products of local and overseas origin to identify their suitability in Latvia. An important role was played by the Laboratory of Toxicology, headed by nostrificated doctor T. Ipatova. The Laboratory was involved in assaying dynamics of chemical compounds and behaviour of waste in plants and soil (nostrificated doctors G. Gorkuna and S. Zikova).

The research results were published in collections of research papers issued by local, all-union or Baltic Region conferences, as well as disseminated through print media, lectures, etc. A number of textbooks were published summarising information that is useful for scientists and farmers up to this day: “Weed control with herbicides” (Gurskis, Mičene, Ozoliņš, 1962), “Biometric analysis of agricultural trials” (Rasiņš, 1971), “Plant protection manual” (authors – experts of Baltic Affiliation; Augu aizsardzības ..., 1972), “Pests of cruciferous plants and their control” (Cinītis, Razauska, 1973), “Plant Protection” (Auziņa, Auns, 1981), “Methods of weed recording in Latvian SSR” (Rasiņš, Tauriņa, 1982), “Keybook of the main weeds found in crop fields and gardens by

easily noticeable features" (Rasiņš, 1987), and "Plant protection manual" (compiled by M. Mičene; Mičene, 1987).

In the 1980s, the number of staff members at VAAZPI Baltic Affiliation reached about 100, including 30 research associates, of them 13–15 nostrificated doctors of biology and agriculture. Since 1979, the institution was headed by director J. Circens.

All research groups continued development of plant protection systems and their enhancement for restriction of harmful organisms in crop fields and plantations seeking for more prospective products.

At the start of 1980s, A. Rasiņš initiated research of the noxiousness threshold in the control of grain crop weeds. At the same time, in collaboration with several colleagues, he continued testing the efficiency of retardants in fields under cereal crops.

Important research was carried out in establishment of resistance of different cultivars of cultivated crops against harmful organisms. T. Ipatova studied the resistance of barley varieties against cereal aphids. J. Rapoports' research interest was formulation of immunological criteria to develop crop plants resistant against the main harmful organisms in agriculture. Together with M. Svikle, he worked on implementation of complex plant protection measures for potatoes against the Colorado beetle, improving its forecasting systems and selecting cultivars resistant against this pest.

Studies of biological preparations were continued, and this subject has not lost its importance still today. Already in 1987, research was initiated on application of biological preparations in integrated potato plantations (L. Davidčika, O. Gross) and apple orchards (M. Eihe, O. Gross). R. Cinītis with colleagues of his research group focused on the development of biological plant protection methods in intensive crop farming on the basis of micro-organisms; he also started studies of using pheromone and hormonal preparations for pest control. I. Praļa guided a number of research studies on the efficiency of pheromone traps for baiting of obscure click beetle and on the detection of the critical threshold.

O. Treikale addressed a specific theme: identification of resistance donors of clover against *Fusarium* and other diseases (Treikale, 1988).

Z. Muceniece started research of the oat nematode.

Z. Davidčika, I. Afanasjeva, and O. Gross elaborated diagnostic methods for detection of bacterial and fungal disease agents of potatoes.

Subsequent to restoration of Latvia's independence, significant changes occurred in funding of the institution, which brought about corrections in the research scope and personnel. Scientists were obliged to become very independent, persevering and competitive in order to find ways of implementation of their research potential.

On September 6, 1991, the Institute became the government surveillance institution again and was renamed the Latvia State Plant Protection Centre (LSCPP). Due to shortages in funding, the scope of research projects and the number of researchers was drastically reduced.

In the 1990s, there were 13 researchers at the institute including three with a doctor's degree: Maija Eihe, Vitolds Tumans, and Olga Treikale. The work of the institution was mainly oriented to biological efficiency evaluation and registration of the new plant protection products in Latvia. LSCPP undertook research also within the grant scheme run by Latvia Research Council. Research was conducted on weed distribution in areas under crops and in the soil of Vidzeme region, 1996–2000 (V. Tumans, I. Vanaga), which resulted in outlining the structure of weed populations

in different cultivated crops and crop plantations in districts of Cēsis, Valka, Valmiera, Limbaži and Riga, as well as interconnections were clarified between weed distribution and productivity in spring barley and winter wheat (Vanaga, 2001).

A large step forward was made in development of disease forecast systems and recording methods for potato and apple-tree pests and diseases, 1994–1996 (O. Gross, M. Eihe, etc.), which resulted in development of the integrated systems for control of the harmful organisms. The above-mentioned studies, within the Research Council grant scheme, were implemented together with the Latvia University of Agriculture. The studies commenced earlier on the development of the apple scab warning system were partially continued in 1997–2000 within the national research program "Development and implementation of a competitive and profitable gardening system" (M. Eihe, A. Kļavinska).

New opportunities appeared in the second half of the 1990s, when the Centre was involved in a number of overseas projects. In 1997, the implementation of the project "Harmonisation and improvement of the pesticide efficiency trials in the Baltic Sea region" was launched (the project was completed in 2001–2002) (M. Eihe, A. Kļavinska, I. Vanaga), targeted at creation of a theoretical base and improvement of facilities for conducting efficiency trials of plant protection products at LSCPP in line with Directive 91/414/EEC. In 1998, research was started within the international project "Development and implementation of the decision-making support in integrated plant protection in Latvia" (A. Kļavinska, I. Vanaga). In both projects, which were completed in 2002, the piers from Estonia, Lithuania and Poland worked together with Latvian experts under the guidance of Agricultural Sciences Institute of Denmark.

In 2000, MSc. agr. Ilze Priekule took over the leadership of the institution. LSCPP developed Good Research Practice provisions in accordance with requirements set out in relevant EU directives and consequently set up a trial base in such a way that the efficiency results of plant protection products tested would be applicable in all Baltic Sea countries (at present, the Northern Zone of the European Union).

Over the first years of millennium, the international project "Development and implementation of the decision-making support in integrated plant protection in Latvia" was still ongoing. On disease and pest restriction in grain crops it made use of software PC-P Diseases and PC-P Weeds; and on control of potato blight – NegFry (2000–2002) (the managers of separate project titles were A. Kļavinska, I. Priekule, and I. Vanaga). The studies tested the suitability and efficiency of programs for disease restriction under agro-climatic conditions of Latvia, and whether the thresholds incorporated in the algorithms of the programs indicating when treatments should be applied are relevant for the population development and epidemiology of the harmful organisms found in Latvia (Kopmanis et al., 2006). A project of particular importance was oriented on the market research (TOP) and was funded by the Ministry of Education "On weed distribution dynamics in grain crops under reduced doses of herbicides, development of recommendations for agro-ecological optimisation of weed control measures", 2001–2002 (manager I. Vanaga), trials were conducted within the above project on efficiency of different doses of various herbicides in fields under spring barley and winter wheat for control of the most widespread weeds with the aim of using the obtained results for accumulation of data base PC-P Weeds under agro-climatic conditions of Latvia.

Thanks to the close cooperation with Danish Institute of Agricultural Sciences developed as the result of the project on decision-making support system, a new TOP project was commenced in

2003 on the development of protection system for apple-trees, 2003–2005 (manager M. Eihe). The most important disease of apple orchards in Latvia is apple scab, in control of which the treatment of apple trees with fungicides precisely in accordance with critical weather for the development of the disease is of utmost importance. A portable meteorological station was purchased, funded by the project, and in coordination with Mark Trapman, a scientist from the Netherlands, the testing of the program RIMpro for the apple scab control under agro-climatic conditions of Latvia was carried out. In the course of research, the software was fully adapted for the Latvian circumstances, following a conclusion that the population of *V. inaequalis* prevalent in our orchards is more aggressive and capable of vigorous development under low air temperatures.

An exceptionally important development for the staff of LSCPP was taking part in an international project funded by the EU Fifth Framework Program on prevalence of invasive species – the giant hogweed (*Heracleum sosnowskyi* – prevalent in Latvia, *H. mantegazzianum* – prevalent also elsewhere in Western Europe), its biology and control measures (2003–2005; eight countries were involved) (I. Vanaga, O. Treikale). The project focussed on potential ways of eradicating the population of the giant hogweed both in open areas on fields and on river banks, at the same time regenerating vegetation on land reclaimed from giant hogweed. The efficiency of different giant hogweed control methods was compared, as well as the competitiveness of different mixtures of perennial grasses with giant hogweed shoots and the option to compete out this invasive weed were evaluated (Nielsen *et al*., 2007; Ravn *et al*., 2007).

On 17 December 2004, the state limited liability company "Latvia Plant Protection Research Centre" (LPPRC) was entered into the Commercial Register of Latvia.

Due to growing interest of the Ministry of Agriculture to involve scientists in the development of agricultural industry, the scope of research themes increased and the cooperation among research institutions in addressing these themes became closer. In 2005–2007, researchers of the Centre in cooperation with piers from the University of Agriculture and the State Priekuļi Breeding Institute of Field Crops conducted research on prevalence and epidemiology of rye ergot (I. Priekule). Within the project, the following were identified: localisation of the disease in the winter rye and triticale fields (infected plants were mainly found on the edges of fields at the depth of up to 3 m), crop cultivation conditions promoting the disease incidence in sown areas, susceptible varieties, as well as most efficient treatment products for the control of ergot.

In 2006–2007, research was carried out on recommendable disinfection products and measures for eradication of a dangerous quarantine organism: bacterial ring rot of potato (O. Treikale). Several disinfection products were tested within the project for treatment of potato warehouses, packaging, and machinery. The list of recommended disinfection products with instructions of use was produced as the result.

In 2007–2009, in cooperation with scientists from State Stende Cereal Breeding Institute and State Priekuļi Breeding Institute of Field Crops, within the joint project funded by the Ministry of Agriculture, the researchers of LPPRC conducted research on significant cereal diseases – ear fusariosis, and bunts (O. Treikale, I. Priekule). It was established that winter and spring wheat is most often infected with fungi of *Fusarium* family *F. culmorum, F. poae,* and *F. avenaceum.* Performing tests for pollution detection with mycotoxines (DON, ZEN, T-2), it was established that mycotoxines in wheat grains tested right after harvesting are practically not found despite the fact that under field conditions the ear fusariosis was rather widely distributed. Further research would be required on isolates of Fusarium species found in Latvia and on their ability to form

mycotoxines under agro-climatic conditions of Latvia. Extensive studies were conducted on species of bunts, their incidence in areas sown with different species of cereal crops in Latvia, as well as on the pollution of the planting material. For the first time in Latvia, a new species of fungus was identified – *Tilletia controversa*, an agent of dwarf bunt in wheat (Priekule, 2007).

In 2009, pursuant to the EU guidelines on introduction of integrated plant growing principles in agriculture as of 2014, research was initiated on resistance of the new cultivars of cereals against the most widespread diseases (O. Treikale, B. Javoiša) (2009–2013). The results obtained will be useful for farmers in making buying decisions on more disease-resistant varieties, thus reducing the need to apply fungicides. In this regard, in 2009, scientists of LPPRC were involved in a project funded by ERDF (headed by LLU), on development of harmful organisms of the crop plants and on the noxiousness threshold in marketing, focussing the research on rapeseed pests (I. Apenīte, L. Ozoliņa-Pole) (2009–2012).

Meanwhile, the long-lasting cooperation with the State Institute of Fruit Growing also became closer. Due to the increased consumers's demand for safe, locally produced fruit and berries, the fruit growing industry was gradually turning into a major customer for the plant protection science. In 2005–2006, research was conducted on diseases and pests, their control options in plantations of commercial cranberries and blueberries (M. Eihe, L. Vilka, R. Rancāne, R. Cinītis, I. Apenīte). Within the project, the most harmful organisms found in plantations of the above crops were identified. It was established that over the research period, the most widespread disease was grey mould (caused by *Botrytis cinerea*), while in cranberry plantations *Phomopsis vaccinii*, the quarantine pest was found, which causes withering of vertical shoots (Vilka, 2009), and cranberry tipworm (*Dasyneura vaccini)* was established as the most commercially important pest of cranberries (Apinīte, 2007).

In 2005, studies were continued for setting up the apple-tree scab projection and warning system in Latvia (M. Eihe, R. Rancāne). Guidelines were worked out for fruit growing in Latvia, as well as the system resource base was put in place, acquiring portable meteorological station programs RIMpro (for development projection of apple scab) to secure meteorological data (Rancane, Eihe, Jankovska, 2008). In 2007–2009, in cooperation with the State Institute of Fruit-bearing Plants, a MOA commissioned inventory of the diseases and pests of fruit-bearing plants was commenced in orchards of Latvia (M. Eihe, R. Rancāne, L. Vilka, I. Apenīte, L. Ozoliņa-Pole, R. Cinītis). In 2010, a second phase of the project was started funded from ERDF resources. Within this project, identification of disease agents in commercial cranberry and blueberry plantations was continued paying special attention to organisms *Phomopsis vaccinii* (L. Vilka) and *Colletotrichum* sp. (J. Volkova), which caused rot of ripe blueberries. Regarding that the apple scab is the commercially most important disease in apple orchards, work was continued with the warning system RIMpro for the disease projection, transferring the updated information to growers (R. Rancāne).

In fruit growing, increasing importance is attached to commercial practices friendly to environment, therefore alternative solutions to chemical plant protection products are actively sought. Within the project, biological preparations were tested for control of the strawberry grey rot, apple scab, and ripe rot of blueberries. In sweet cherry plantations, the yield was gravely impaired by European cherry fruit fly *Rhagoletis cerasi*, therefore studies were initiated to investigate the controlling methods of this pests (B. Ralle, I. Apenīte). L. Ozoliņa-Pole is engaged in research of currant clearwing *Synanthedon tipuliformis* (Ozoliņa-Pole, Apenīte, Ciematnieks, 2013).

In September of 2010, due to the shift of shareholders, LAAPC became the property of Latvia University of Agriculture yet preserving status of a legally independent unit – a limited liability company "Latvia Plant Protection Research Centre". However, the administrative changes did not cause adverse impacts to research orientation.

In 2011, LPPRC in a status of a stakeholder institution was involved in implementation of two important projects funded by European Regional Development Fund (ERDF). Under the guidance of LVAI, LPPRC took part in development of innovative technology solutions oriented at mitigation of risks in cultivation of fruit and berry crops. Within the project, it undertook research of disease and pest restriction opportunities in strawberry, raspberry, and sweet cherry areas under cover (R. Rancāne, L. Vilka, J. Volkova, I. Apenīte, L. Ozoliņa-Pole, V. Rožukalne, I. Salmane) (2011–2013). Under the guidance of Latvia State Forestry Institute "Silava," LPPRC is involved in development of environmentally-friendly plant-origin plant protection products on the basis of conifer biomass, testing the efficiency of these novel products for disease restriction in strawberry, raspberry, onion, cabbage, and pine-tree plantations (R. Rancāne, J. Volkova, V. Rožukalne, O. Treikale, B. Javoiša, M. Vilcāns) (2011–2013).

In 2012, LPPRC was involved in an international project targeted at biological methods of pest control in areas under strawberries and raspberries, testing the opportunities of applying insect sex pheromone and fruit scent traps as baits for catching of the black anthonomus tarnished plant bug (EU 7th Framework Program, ERA-NET, CORE organic II, 6 countries; 2012–2014) (I. Apenīte, B. Ralle).

In 2012, under the guidance of Latvian State Institute of Fruit Growing (LVAI) LPPRC, within the project funded by ERDF, the 3rd stage of studies of pests and diseases in plantations of fruit-bearing plants was launched, this time paying much closer attention to identification of disease agents with methods of molecular biology (2012–2014). The fruit rot prevalence was surveyed in plantations of the sour and sweet cherries to ensure identification of two main agent species: *Monilinia* sp., and *Colletotrichum* sp. Observations of strawberry resistance to powdery mildew were started. R. Rancāne started addressing the pear scab, a problem largely neglected in Latvia up to now. Closer attention globally is being paid to sanitation measures of the disease load reduction in areas under crop plants, therefore research was initiated in Latvia on the efficiency of sanitation measures in disease control of fruit-bearing plants. In orchards, a serious damage is caused by European shot hole borer *Xyleborus dispar*, therefore Entomology Group of LPPRC commenced research on the prevalence and control measures of this pest in fruit gardens.

Over the whole time span since 1980 up to nowadays, all research groups of the Centre are involved in extensive research studies in testing of the new plant protection products placed on the market by overseas companies for clarifying their efficiency under conditions of Latvia. Overall, 200–240 trials on the average are carried out on annual basis, testing efficiency of herbicides, growth regulators, fungicides, insecticides, limacides and pesticides of other groups in areas under grain crops, pulses, rapeseed, potatoes, corn, perennial grasses, fruit-bearing plants, vegetables, and other cultivated crops.

One of the prime tasks of today is renovation and expansion of the research potential. After the rather dramatic crisis of 1990, when the number of researchers reduced by at least 8 times, at this stage, the Centre is involving another new staff member each year. The current experts continue to upgrade their qualification. The staff of LPPRC is very satisfied with achievements

of the young scientists Ilze Apenīte and Ineta Vanaga, who defended their doctoral theses in May of 2010. Currently, another four of our staff members – L. Vilka, R. Rancāne, J. Volkova, and L. Ozoliņa-Pole – continue their doctoral studies. It should be emphasized that promotional theses are elaborated on the basis of research projects implemented at the institution. Having five researchers with the doctor's s degree and 11 staff members with the master's degree on our payroll is a proof of the high qualification of our employees.

We believe that only through continuous intellectual advancement and assertion of our creative potential in research projects, at the same time keeping close ties with the farming community – primary producers of agricultural products –, LPPRC can keep its important role in agriculture and certify its competitiveness in the local and international domain of science.

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Forecasting and Warning Systems for Pests and Diseases of Field Crops

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Abstract. Pests and diseases of agricultural crops can cause great yield reductions in terms of quality and quantity. To prevent such reductions, use of pesticides (insecticides, fungicides, and herbicides) increased in recent decades in most European countries. However, the negative effects of pesticides also became more obvious during this period. In order to minimise the impact of pests and diseases on field crops, it is important to use several control methods that are non-damaging to the crop, but damaging to the target pest or disease. Pesticides must also have a minimal impact on non-target organisms and be accepted by society. In several European countries, including Sweden, there is great interest in reducing the use of chemicals in agriculture and in developing a more environmentally sound agricultural system. Forecasting and warning systems for pests and diseases play an important role in Integrated Pest Management (IPM) and in farm advisory work. This paper describes forecasting and warning systems for pests and diseases in Sweden, the impact of climate change on pests and diseases of field crops in the Baltic Sea Region, and collaborations in crop protection between the Baltic and Nordic countries, in particular between Sweden and Latvia.

Introduction

Pests and diseases of agricultural crops can cause great yield reductions in terms of quality and quantity. To avoid such yield reductions, there was increased use of new, highly effective pesticides (insecticides, fungicides, and herbicides) during recent decades in most European countries. However, the negative effects of these pesticides also became more obvious during this period. In order to minimise the impact of pests and diseases on field crops, it is important to use a number of methods that are non-damaging to the crop, but damaging to the target pest or disease. A combination of control techniques can be used in a particular cropping system, including cultural practices, crop rotation, use of resistant varieties and chemical treatment only when there is a real need. Pesticides must also have a minimal impact on non-target organisms and be accepted by society. In several European countries, including Sweden, there is great interest in reducing the use of chemicals in agriculture and in developing a more environmentally sound agricultural system. Forecasting pest outbreaks during the growing season and applying control measures only when necessary is very important in conventional farming, but also in organic farming, to increase profitability while, at the same time, minimising negative effects on flora, fauna, and groundwater.

Forecasting and warning systems for pests and diseases play an important role in Integrated Pest Management (IPM) and in farm advisory work. This paper describes the forecasting systems for pests and diseases in Sweden and the warning system linked to these, the impact of climate change on pests and diseases of field crops in the Baltic Sea Region, and importance of collaborating on IPM in the Baltic and Nordic countries.

Economic importance of pests and diseases

A number of pests and diseases cause great yield losses in Sweden. Some of the major agricultural crops affected are cereals, oilseed rape, potatoes, sugar beet, and peas. Yield losses can vary greatly between years and between regions of the country within and between years.

Aphids are the most important insect pests on cereals. They not only cause direct damage but also transmit virus diseases. Aphicide treatments are profitable on about 70% of national barley and oat crops during years with heavy outbreaks of cereal aphids, especially *Rhopalosiphum padi.* In years with low attacks, spraying is only profitable on 10% or less of the cereal crop. Other insects of great economic importance include wheat blossom midge on wheat, frit fly on oats, blossom beetle on rapeseed, and various aphid species on potatoes, sugar beet, oilseed rape and peas.

Economically important fungal diseases include powdery mildew and leaf spot diseases (*Septoria nodorum, S. tritici, Rhynchosporium secalis, Drechslera teres*) on cereals, especially on winter wheat and barley, *Sclerotinia sclerotiorum* and *Alternaria brassicae* on oilseed rape, late blight on potatoes, barley yellow dwarf virus (BYDV) on cereals, and potato virus Y (PVY) on potatoes. Forecasting methods have been developed for some of these pests and diseases in Sweden.

The economic importance of different pests and diseases has been estimated in different crops in Sweden, partly based upon surveys carried out every year and field experiments with treatment against pests and diseases. Using the results obtained, economic threshold values have been estimated for the most important pests and diseases in cereals, sugar beet, potatoes, and oilseed rape. Estimates of the proportion of area that can be profitable to treat against pests or diseases are based on the cost of treatment (chemical, tramlines, and driving) and on the value of the yield increase (Table 1).

Table 1

Estimated yield increase obtained by treatment of pests and diseases in barley. 10-year mean. Proportion of area in different classes

Yield increase	Diseases	Aphids
Dt ha^{-1}	% area of barley	% area of barley
0–2	50	30
2–4	30	25
4–6	20	20
6–8	10	10
8–10	5	5
10–12	3	5
12–14	2	2
14–16	0	1
16–18	0	1
18–20	0	1

Forecasting methods

Aphids on cereals

In Sweden, *Rhopalosiphum padi* is the most important aphid species on cereals, especially on oats and spring barley, but *Sitobion avenae* is also of some importance in southern Sweden. Because of the great variation in attack intensities between years and regions of Sweden, accurate forecasting methods are needed. For example, it is important to estimate the general need for aphicides long (several months) before the actual spraying, to allow time for delivery. However, specific forecasts can only be made a few weeks in advance. Thus, both long-term and short-term forecasting methods are needed.

For more than 30 years, suction traps have been used in Sweden to relate numbers of autumn- and spring-migrating aphids to the intensity of attacks on cereals and other crops, partly to develop the capability for making long-term forecasts. Aphid migration has been studied for about 20 years in Sweden, especially with regard to *R. padi* (Wilktelius, 1981). For about 30 years, 7-9 suction traps have been used in Sweden, at sites ranging from the extreme south to the north of the country. The distance between the most southerly and most northerly traps is approximately 1600 km.

In Sweden, *R. padi* overwinters as an egg on *Prunus padus*. The migration during autumn has a great influence on the number of eggs laid on the winter host and on the number of spring migrators. Determining the number of autumn migrators (data from suction traps) gives rather good information on the risk of attack in the following year, and the relationship between number of overwintering eggs and proportion of fields above the damage threshold is almost the same (r^2=0.4), but that between spring migration and proportion of fields above the damage threshold is even stronger (r^2=0.7). In some years, unfavourable weather (i.e. low temperatures and rainfall) makes it difficult for the aphids to migrate to spring cereals, and during such years the severity of attack is much lower than the predicted based on the winter egg counts. Under such conditions, suction traps give good information about the risk of attack by *R. padi* on spring barley and oats.

In 1987, there were very few aphids in cereal fields and no need for chemical treatment against aphids in cereals. However, in autumn 1987 there was a great migration, indicating that 1988 could be a problematic year if there were good conditions for spring migration. The results from suction trap catches showed that there was a great risk of severe attack by *R. padi* in 1988, and the results from field surveys later showed that about 70% of spring cereal fields in central Sweden had to be treated against aphids. Thus, forecasts together with a good warning system and observations in the specific field give the farmer a good basis for decision-making.

For several years there has been collaboration between European countries concerning suction trap catches and aphid migration. About 20 countries are participating, providing data from 80 suction traps in Europe (EXAMINE: http://www.rothamsted.ac.uk/examine/) (Fig. 1).

Wheat blossom midge

During some years, wheat blossom midge (*Contarinia tritici* and *Sitodiplosis mosellana*) is of great economic importance in winter and spring wheat. Severe attacks by the larvae cause considerable yield losses, amounting to 20–30% in some fields. However, severe attacks are infrequent, which is an important fact to consider when making a decision on spraying. For more than 20 years, annual surveys have been carried out every year in wheat fields in central and southern Sweden. In each

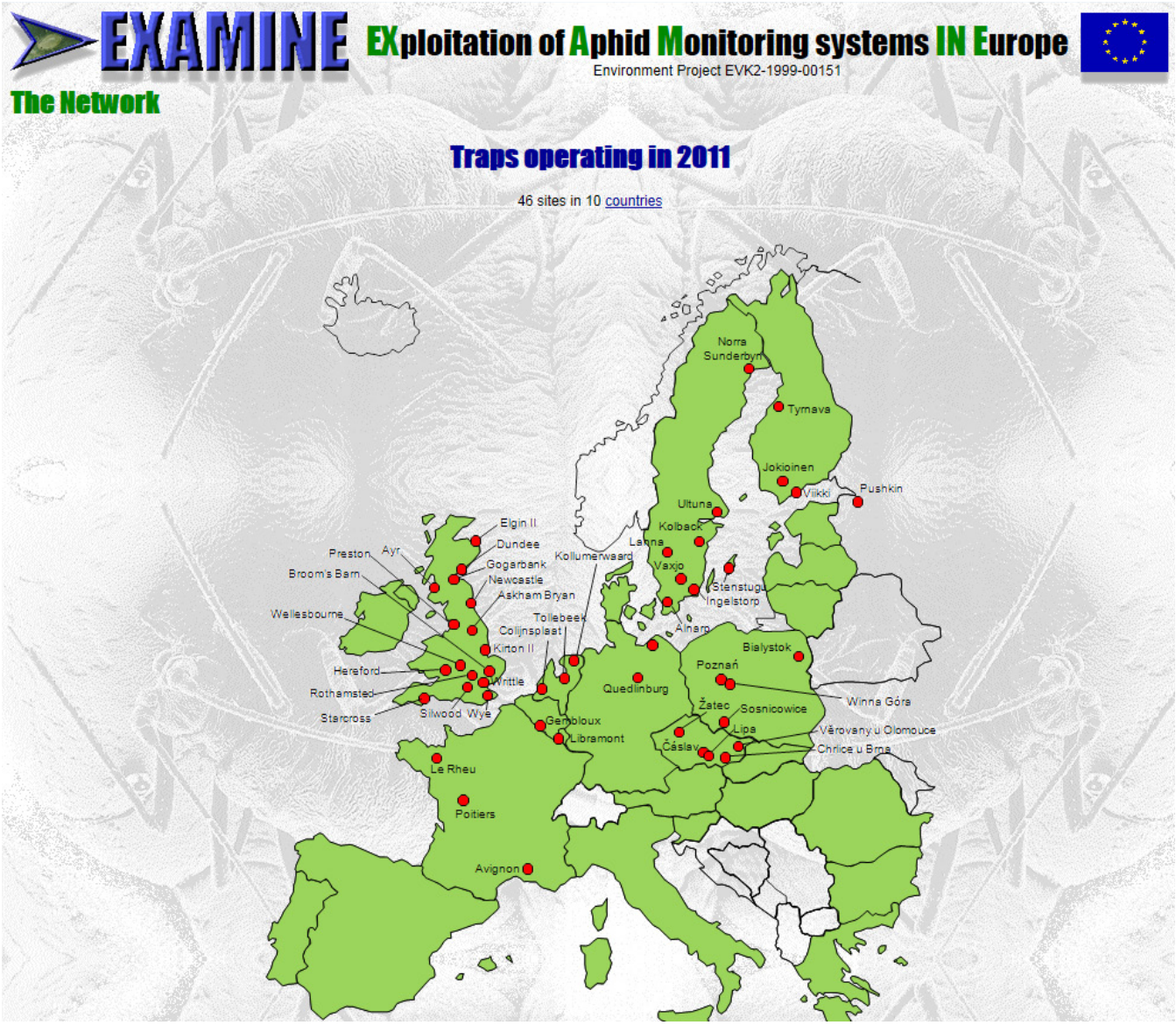

Figure 1. Map showing the location of suction traps in Europe.

field, grain sampling has been carried out to obtain information on wheat midge populations. This information, together with weather data during the growing season, allows the risk of attack by the midges to be estimated.

Frit fly on oats

Frit fly (*Oscinella frit* L.) is a stem-boring fly which causes damage to cereals and grasses in many countries. In Sweden it is an important pest especially on oats, and can cause losses of up to 50%. Chemical control is based on the prevention of egg laying by application of a pyrethroid before two-leaf stage. Therefore, the farmer has to decide the need for spraying early in the cropping season. To avoid routine spraying and at the same time apply insecticides when it is profitable, a reliable forecasting method is needed.

Since 1985, a method developed in Sweden has been used in practice by advisory services and farmers. An important factor to consider is timing between insect and plant development, and also population level and weather during the egg-laying period. The method is partly based on

meteorological data, biological observations and sampling (Lindblad and Sigvald, 1999). Sunshine hours in the previous year and suction trap catches give a good estimate of the present population level. During spring and early summer the temperature sum is calculated (base temperature +8°C), which gives an accurate prediction of when migration of frit fly will take place. Weather data such as temperature are also considered, because this has a great influence on frit fly activity and egg laying (Lindblad, 1993; Lindblad and Solbreck, 1998).

Based upon research data, a number of risk factors are considered when estimating the risk of attack in a specific field. The method has been validated in more than 800 oat fields. There is very good agreement between risk assessment (risk points in the specific field) and the proportion of main stems infested by the larvae. The method is now widely used by farmers.

Potato virus Y

Many aphid species are important vectors of non-persistently transmitted viruses. Most viruses transmitted by aphids in a non-persistent manner are believed to be acquired and transmitted within fields through probing by aphids flying from plant to plant. PVY is transmitted mainly by aphid species that do not feed on the crop that they inadvertently infect (Sigvald, 1986). After probing for 5–10 seconds, the aphids acquire the virus and are immediately able to transmit it to other plants. However, most aphids only remain infective for about 30 min.

In Sweden and many other countries in northern Europe, PVY is one of the most important virus diseases on potatoes (Sigvald, 1990). During the past decade there has been increasing interest in developing methods for PVY forecasting. The main variables used when forecasting the incidence of PVY include the number of winged aphids and their vector efficiency, the time of aphid migration in relation to plant age, and the availability of virus sources (Sigvald, 1985, 1986). However, the degree of spread of PVY varies greatly between regions and years. In northern regions of Scandinavia, the spread of PVY is minimal because vectors are uncommon. In contrast, in southern regions the spread of PVY has led to serious problems for seed potato growers during some years. Nevertheless, few fields are infected so severely as to warrant rejection of the seed potatoes produced.

In Sweden and several other countries, suction traps have been used in aphid forecasting. There are often great differences in trap catches between years and regions. In Sweden, *R. padi* is the most common aphid species caught in the traps in southern, central and northern parts of the country in most years. In 1989, there was a great difference in suction trap catches between southern and northern Sweden (Table 2). Several aphid species were more commonly trapped in southern Sweden than in northern regions, especially *Acyrthosiphon pisum*, *Aphis fabae*, *Brachycaudus helichrysi*, *Metopolophium dirhodum*, and *R. padi,* which resulted in a great spread of PVY in southern regions in that year.

There are also examples from other countries of Europe where *R. padi* plays an important role in the spread of PVY. In 1976, there were large migrations of *R. padi* in both western and northern parts of Europe and this was probably the main reason for the great spread of PVY during that year. Differences between years and regions in aphid migration have a great influence on the spread of several aphid-borne plant viruses, including PVY, and this is very important to consider in seed potato production.

Results from suction trap catches in Sweden show that there is a rather weak relationship between the total number of winged aphids and proportion of PVY-infected progeny tubers, but the relationship is stronger when only the main vectors of PVY are taken into account (Sigvald, 1984,

Table 2

Number of aphids caught in suction traps in southern and northern Sweden, 1989.

Aphid species	Southern (M)			Northern (AC)		
	May	June	July	May	June	July
Acyrthosiphon pisum	18	77	263	0	0	0
Aphis sp.	7	67	558	0	0	0
Brachycaudus helichrysi	104	400	983	0	0	0
Metopolophium dirhodum	10	158	664	0	0	0
Myzus persicae	0	0	0	0	0	0
Phorodon humuli	2	37	83	0	0	0
Rhopalosiphum padi	45	2405	6482	0	165	136
Other aphid species	234	2161	3646	2	88	136

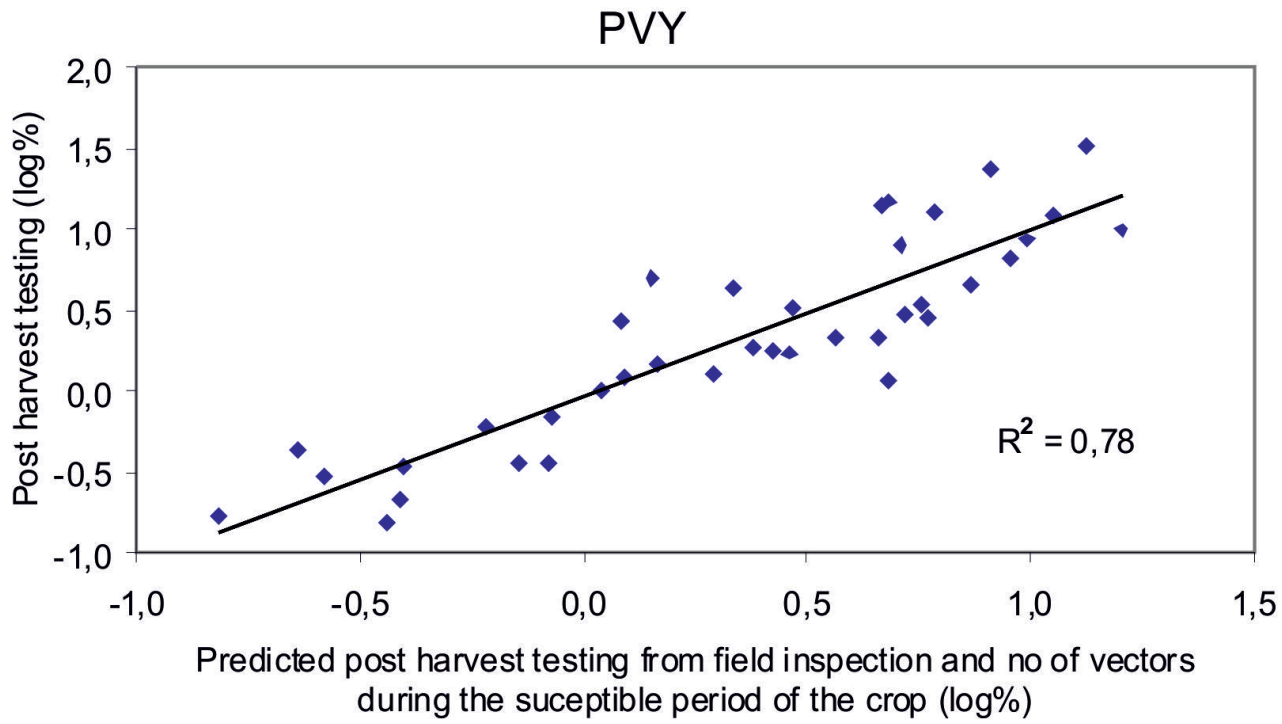

Figure 2. Relationship between total number of aphids in suction traps in different regions and years and post-harvest testing of progeny tubers.

1985). The relationship is very good when the effect of mature plant resistance and proportion of virus sources are also taken into account (Sigvald, 2012) (Figure 2).

Forecasting late blight on potatoes

Interest in reducing fungicide use in potato cropping has led to increased efforts to develop methods for forecasting the risk of late blight (*Phytophthora infestans*) in potatoes. Late blight attacks in potatoes in Sweden differ greatly between regions and years.

During the past decade, a few models for late blight in Sweden have been evaluated (Andersson, 1994). The daily weather data needed are automatically transferred from the Swedish Meteorological and Hydrological Institute to the Swedish University of Agricultural Sciences. The forecasting method indicates that treatments recommended by the model are close to actual requirements and less than routine spraying, but further studies will have to be carried out to make the forecasts more reliable.

About 20 years ago, the mating type A2 of *Phytophthora infestans* was discovered in Europe and in 1986 in Sweden. During the past decade there has been increased interest in investigating the occurrence of A2 in a number of countries in Europe, including Sweden. Since 1995, observations in Sweden and other European countries have indicated the presence of soil-borne inoculum of late blight (Andersson *et al*., 1998; Andersson, 2007). In potato fields in Sweden, both mating types A1 and A2 were isolated in 1996 and 1997 and oospores were found on leaves and stems, as well as in stolons. The importance of soil-borne inoculum of late blight for early infections is of great interest.

Sclerotinia stem rot

Sclerotinia stem rot (*Sclerotinia sclerotiorum*) is one of the most important diseases on spring-sown oilseed rape. During years with high humidity, the yield reduction can reach 60% in heavily infected fields, and in such years chemical treatment is profitable in 40-60% of fields. Sclerotinia stem rot can be effectively controlled by fungicide treatment during full flowering. Routine spraying is not profitable, since the cost of chemical treatment is high and disease incidence varies greatly between years and regions and also between fields within a region, thus justifying a forecasting system.

A method for forecasting the incidence of Sclerotinia stem rot has been developed in Sweden (Twengström & Sigvald, 1993). Besides field experiments and laboratory studies, data from more than 800 fields have been collected to improve the method, as well as for validation of the risk assessment. The method is mainly based upon a number of risk factors, such as crop density, crop rotation, level of previous Sclerotinia infection (estimation of inoculum in soil), time of apothecia formation from sclerotia, rainfall during early summer and during flowering, and weather forecast. An initial risk assessment showed very good agreement between risk points and Sclerotinia stem rot incidence. To further improve the model, specific field data were analysed by logistic regression. The results showed that the model could be simplified and still give very good or even better predictions (Yuen *et al*., 1996; Twengström *et al*., 1998).

The method has been used by farmers during the past decade. It has been available in the form of risk points, but during recent years also interactively via the internet. Since the method was introduced about 20 years ago, the proportion of fields profitable to spray has increased, and today there is very good agreement between the need for spraying and actual treatments. The great success of the forecasting method for Sclerotinia stem rot is probably to a great extent due to the fact that advisory services and farmers have participated in validation and implementation.

Warning systems for pests and diseases in Sweden

There is a great need for effective warning systems for pests and diseases. Growers need information about the risk of attack by different pests and diseases long before spraying. Warnings are especially critical when high levels of attack are expected, which would lead to severe losses if farmers were unprepared.

For more than 25 years a warning system has been under development in Sweden in a partnership between the Swedish University of Agricultural Sciences and the Swedish Board of Agriculture. In each of five regions, there is a Regional Plant Protection Centre to organise the work and handle the local information about the actual situation, which is then presented via the internet for different pests and diseases. Such information and availability of forecasting methods for different pests and diseases is very important in IPM. In southern and central Sweden, more than 1200 fields representing a variety of crops are inspected weekly. When the weekly analysis is ready, a summary is made available to the farm advisory service in the region via the internet. The day after the field evaluations are received, each Plant Protection Centre holds a telephone conference with advisors in the region concerned.

Impact of climate change on pests and diseases of field crops

Climate has a great influence on the occurrence of pests and diseases of field crops. Dry conditions are often favourable for insect pests, and wet conditions – for fungal diseases, but there are several other factors which have a great influence on pest and disease development. Calculations of the damage to crops as a function of climate are complicated, and research within this area is working to develop methods for both understanding and predicting the effects of climate change on the dynamics of insects and diseases (fungal, viral, bacterial) and on the damage they cause to crops.

Insect attacks on crops will probably increase in the future. There are several reasons for this. Higher temperature will increase the number of generations during the growing season, and warmer climate during the winter will be favourable to insects and they will probably survive and therefore be more numerous in the spring. Aphids are very important in many countries of the world not only because of direct damage since they feed on the crop, but also because of indirect damage through the ability to transmit various viruses. In Sweden there are more than 50 aphid species of great importance for various crops. Some of these species will probably survive during mild winters, and most regions of Sweden will probably experience increased problems with damage caused by insects and virus diseases, but the increase will be greatest in southern Sweden and in dry areas. Insects will be active considerably earlier in the spring than at present since the growing period will be extended. However, in some regions more rain is expected in late winter and early spring, and therefore sowing time can be delayed and earlier attack by insects can be expected in comparison with developmental stage of the crop. The greater numbers of aphids at spring sowing and the fact that spring crops will be exposed to virus diseases at an earlier stage of development will increase the need for pesticides unless there is an increase in other methods, such as use of resistant varieties.

Aphids and virus attacks in autumn are currently limited, but the future climate will bring about great changes. The number of aphids (vectors of virus diseases) is relatively low at present, but milder autumns and 3–4°C higher winter temperature will have a great influence. Some aphid species such as *Rhopalosiphum padi* will probably survive during the winter on grasses and winter cereals. Winter wheat and winter barley can be infected with BYDV by *R. padi*, which is an important vector of BYDV. *Sitobion avenae* will also contribute to transmission of BYDV on winter cereals. This will increase damage by aphids and viruses and will increase the need for insecticides in winter cereals. Aphids can also transmit viruses of winter oilseed rape, and the future warmer climate will probably increase numbers of such vectors and increase problems with viruses in this crop.

In autumn 2006, the weather in southern Sweden was very mild, which was very favourable to aphids. Winged aphids, mainly *R. padi*, were trapped in the suction trap in southern Sweden until

late November. This indicated that *R. padi* could be a problem in winter wheat in the following year because of its ability to transmit BYDV. In early spring 2007, many winter wheat fields showed symptoms of BYDV. Analyses of samples from southern Sweden showed that fields were infected with BYDV, mainly the PAV strain. There were great differences in virus incidence in wheat fields in southern Sweden, from very low to high. In some fields, the yield reduction was probably more than 25%.

In a future warmer climate, there will probably be more aphids in the autumn, while newly introduced spring-sown crops such as maize that grow long into the autumn can act as a green bridge for viruses from spring-sown to winter-sown crops. Therefore virus attacks will increase on winter wheat and winter barley. New insect pests will probably become established in Sweden, depending on the crops grown and on winter conditions, but it is difficult to predict the insect species involved and a monitoring system is needed to follow developments in this area. Colorado beetle is one example of an insect pest that will probably be introduced in the coming 20 years. This will cause great problems for potato growers.

In most crops, moisture and higher temperature are favourable to fungal diseases. In some regions of Sweden with more rain during the growing season in future, we can expect greater attacks of late blight in potatoes. On the other hand, there may be drier conditions in south-east Sweden and thereby less problems than today. Winter cereals will be particularly vulnerable, since they will have a long infection period in the autumn and thus diseases such as brown rust will increase. For spring cereals, the effect can be less than at present in areas with a predicted relatively dry early summer period, such as southern areas of the country. In northern Sweden, fungal diseases of cereals will probably increase due to the generally wetter and warmer climate.

In the future warmer climate with more aphid species also in northern parts of Sweden, seed potatoes will run a greater risk of virus attacks than at present. The need may then arise to establish special areas for seed potato production in which cultivation of ordinary commercial potato crops with a high proportion of virus-infected potato plants is restricted. Increased incidence of different insect pests on most crops will increase the use of pesticides, an undesirable development from a number of perspectives. Improved cropping systems, increased use of resistant varieties, and a good crop rotation to decrease the occurrence of pests and diseases will therefore be of increasing importance.

Collaboration between the Nordic and Baltic countries on pest control

It is almost 100 years since collaboration on agricultural research started between the Nordic countries through the Nordic Association of Agricultural Scientists (NJF). There are now eight member countries, since the Baltic countries became members a few years ago. Some researchers from other countries are also individual members.

The main goal of NJF is to promote and develop interactions (networking) between scientists, advisors, teachers and administrators, and between agriculture, agricultural research, industry, consumers and society. The main activities are carried out within five sections: Plants, Animals, Environment, Economics, and Technology. Seminars are the main activity, with some attracting more than 200 participants and the overall results and most individual presentations are published on the NJF website (www.njf.nu).

In 2012, relevant seminars in crop protection, crop production and sustainable agriculture included “Integrated Pest Management, Sustainable agriculture in the Baltic Sea Region with focus

on climate change, Local food – a step towards better and more environmentally friendly products, Nordic Baltic Fusarium seminar" and "Past and future in Nordic nematology".

Besides seminars, there are other activities within NJF to promote networking within the Nordic and Baltic countries. The National Associations in each country play an important role in making contact with members, policy makers, advisors, companies, etc.

Collaboration between Latvia and Sweden in crop protection over 20 years

Over the past 20 years, Sweden has had many activities in collaboration with Latvia, especially in the area of crop protection and forecasting and warning systems for pests and diseases. In 1992, a professor from the Latvia University of Agriculture visited the Swedish University of Agricultural Sciences for about three months to work in the areas of general crop protection and forecasting methods, production of virus-free seed potatoes, and seed potato certification.

A project on "Forecasting and warning systems designed for plant protection in Latvia, 1995–1998" was set up to establish IPM programmes in Latvian agriculture, primarily in an effort to minimise the adverse impacts of pesticides on the country's flora, fauna, drinking water, and environment. The main objectives of this project were to:

a) adapt warning systems;
b) build up a knowledge base concerning economic thresholds;
c) adapt forecasting methods;
d) disseminate general information on plant protection.

This project included a PhD programme in sustainable use of natural resources funded by the Royal Swedish Academy of Forestry and Agriculture. One PhD student studied the epidemiology of BYDV with the aim of developing forecasting systems based on aphid monitoring. Different BYDV strains were diagnosed and characterised using ELISA, and DNA techniques were used (Bisnieks, 2006).

Besides these activities, courses for postgraduate students from the Baltic countries, Poland and Russia have been organised in Latvia on the subject of management aspects of crop protection, sustainable agriculture and decision support systems in crop protection. With better collaboration between neighbouring countries, forecasting and early warning systems for pests can be improved, ultimately reducing the use of environmentally damaging pesticides.

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Veterinary Scientists and Research at the Faculty of Veterinary Medicine 1919–2013

E. Birģele, A. Mugurēvičs, V. Antāne, E. Liepiņš

The years 1919–1920: foundation of the Faculty of Veterinary Medicine
The years 1920–1939: first docents–scientists and their research

The history of veterinary science began in September 1919, when the Faculty of Veterinary Medicine was founded at the University of Latvia (till 1923 – called The Latvia Higher School) and veterinarian Voldemārs Brencēns started working there. A year later, in 1920, he was joined by Ludvigs Kundziņš and Rūdolfs Grapmanis – both of them brought their own scientific and administrative work expertise.

Voldemārs Brencēns graduated from Tarbatu (Terbata) Veterinary Institute in 1910. Besides being an excellent organizer and teacher, V. Brencēns also devoted himself to research. He developed rules for containment of contagious diseases in domestic animals, and in later years together with veterinarian Jānis Pētersons developed a new surgical method for correction of wind sucking in horses. In veterinary literature this method is described as myectomy by J. Pētersons. Together both veterinarians designed the ether and chloroform inhalation mask for general anesthesia of horses. Among V. Brencēns' scientific publications, "Equine aerophagia and its surgical treatment" should be highlighted as his life's work.

Ludvigs Kundziņš graduated from Terbata Veterinary Institute in 1881. He became professor of anatomy at the Faculty of Veterinary Medicine of the University of Latvia (FVM UL) in 1920, after transferring from the position of anatomy professor at the Faculty of Veterinary Medicine of the University of Tartu.

Professor L. Kundziņš had studied embryonic development of mammalian (*Aplacentalia* and *Placentalia*) bones, especially skull. The professor established an anatomy museum of domestic animals, as well as evaluated animal bones from archeological excavation sites at Taniskalns, Daugmale castle hill and settlement at Zebrus Lake. Ludvigs Kundziņš is considered to be the founder of Latvian school of veterinary morphologists and embryologists. Under his supervision and mentorship, dissertations in comparative embryology were defended by Rūdolfs Grapmanis (1931), Arturs Vītums (1936), and Pāvils Ozoliņš (1937). In 1935, the journal *"Morphologisches Jahrbuch"* (Morphological yearbook) published the article of L. Kundziņš *"Űber die Vorderextremitäteines 12 mm langen Pferdeembryos nebst einem Berichtüber das Coracoid dreier Beuteljungen von Antechinomys laniger"*.

Rūdolfs Grapmanis graduated from Terbata Veterinary Institute in 1910, and from 1920 he worked at the Faculty of Veterinary Medicine. R. Grapmanis had studied histological changes in equine flexor tendons caused by various medications of aseptic inflammation. He published the study "Embryonic development of equine sex glands, especially ovaries", as well as carried out a variety of studies in animal-derived nutrient hygiene and inspection. R. Grapmanis was also interested in pathological morphology of animals (together with Milda Skudiņa he established a museum of pathological morphology of animals) and in issues of meat inspection. Important to notice that Prof. Rūdolfs Grampanis is also author of the first

textbook on meat hygiene published in Latvian on 1938 "Meat hygiene and meat technology" ("Gaļas higiēna un gaļas tehnoloģija")

So, from the early days of FVM, several research directions can be recognized which became broader after establishment of separate departments within the Faculty. The main research directions at that time were: control of contagious diseases of domestic animals, surgery, veterinary morphology and comparative embryology, pathological morphology, and food hygiene and inspection.

In 1925, professor L. Kundziņš hired Pāvils Ozoliņš, graduate of the FVM UL, as a junior assistant at the Department of Anatomy; later P. Ozoliņš became a key figure in veterinary anatomy in Latvia. He is the author of 10 scientific publications and two fundamental textbooks – "Anatomy of Domestic Animals" (1956) and "Anatomy of Farm Animals" (1975). Professor P. Ozoliņš had studied the development of the skeleton of front limb in porcine and equine embryos, as well as the blood vessels of birds. One of the most significant P. Ozoliņš' publications is "*Plexus brachialis* and *plexus lumbosacralis* development in porcine and equine embryos", which was published in *"LU Raksti"* (scientific journal of the University of Latvia) in 1937. Concurrently, Pāvils Ozoliņš actively participated in the Committee of Terminology at the Academy of Science, establishing Latvian equivalents for several thousands of anatomical and physiological terms.

In the field of veterinary anatomy and embryology, worked also Arturs Vītums: from 1929, as a subassistant at the UL Institute of Pathological Anatomy; later as a junior assistant; afterwards – an assistant, a senior assistant and a private docent until emigrating to Germany in 1944. A. Vītums studied the development of lungs and aorta in horses, as well as the structure of the pituitary gland, its vasculature and vascular anomalies. His study about embryonic pulmonary development in horses was published in *"LU Raksti"*; for this work A. Vītums was awarded the first prize of the Culture Fund in 1937. A. Vītums' study *"Űber den Schlingrachen bei Haussaugetieren"* was also published in "LU Raksti".

In 1923, Milda Skudiņa (maiden name Salmiņa) started her work as a subassistant at the Department of Pathological Anatomy. She was the first woman who graduated from the FVM UL. Among her research interests were diseases of fish, crayfish, and bees, as well as pathomorphological processes of animal diseases. At that time, M. Skudiņa started to study morphology of equine colics, and prevalence of fish and crayfish diseases in Latvia. She participated in the conference devoted to control and eradication of crayfish plague in Finland in 1928, and in the Baltic States' veterinary conference in Kaunas in 1937. In 1933, M. Skudiņa published her study *"Űber die Beziehungen der Langerhansschen Inselnzu den Pankreasausführungen bei Cyprinus Carpio"*, and in 1934 – a review of crayfish diseases in Latvia.

Otto Janovskis, already as a student at the Faculty of Veterinary Medicine, studied histology and later became docent of the same Faculty. In 1935, O. Janovskis received the first prize for his work "Assessment of the value of meat products with histological methods".

During the first years of the Faculty of Veterinary Medicine, research in internal non-infectious diseases was carried out by professor Kārlis Kangro, who started his work at the Faculty in 1921 as a docent. He studied stenosis of nasal passages in mammals and pathology of maxillary sinuses. In 1927, his study *"Beiträge zu Frage des Vorkommens und der Bedeutung der stenosen lateralen Nasendrüse der Säugetiere, sowie der Drüsen des* Sinus maxillaris*"* was published.

The beginning of research into the specialty of veterinary surgery is the year 1935, when Adolfs Alksnis started studying the improvements in radiographic diagnostics, and pathology of joints and hoofs; later he became a private docent at the FVM UL. In Vienna, in 1938, A. Alksnis defended his

doctoral dissertation about radiographic anatomy of normal joints in horses, dogs, and cats, which was published in *"LU Raksti"* and received a prize of the Culture Fund in 1938.

At the same time, assistant of the FVM Department of Surgery Broņislavs Rudiks defended his doctoral dissertation *"Űber Rindbildungen an pathologischen Hufen"* in Vienna Veterinary School.

Blood transfusion in mares after complicated foaling was studied by docent Pēteris Mežaks. His most significant publications were "Diseases of domestic animals" (1936) and "Piglet liver ailment and its treatment in Latvia" (1939). Later, in 1943, P. Mežaks published "Plagues and diseases of domestic animals".

Foot and mouth disease was studied by Pēteris Arnolds Apinis, who concurrently was also an excellent clinician. Professor Apinis studied treatment of gangrenous pneumonia in horses, hematological changes during contagious equine pustular stomatitis, and prevention of poultry and porcine diseases depending on husbandry and management. In Vienna, in 1936, P.A. Apinis received his Dr.med.vet. degree. In 1937, the journal *"Tierärztlische Rundschau"* published the scientific study of P.A. Apinis *"Das Blutbild bei der Stomatitis pustulosa contagiosa egui"*. In 1938, the "Veterinary Journal" published P.A. Apinis' study "Treatment of equine gangrenous pneumonia".

From 1930 to 1943, research in contagious diseases of domestic animals was organized and led by professor Miķelis Rolle. Under his leadership, proposals for guidelines for the control and eradication of infectious diseases of animals and for the sanitary inspection of milk and dairy products were prepared. M. Rolle established the Institute of Hygiene, where students studied infectious diseases, parasitology, health care for livestock, general microbiology, dairy microbiology, hygiene, and technology. M. Rolle defended his doctoral thesis *"Biologie des Bacterium pyogenes"* in Germany and received the degree of Veterinary Medical Doctor.

Professor of the Veterinary Faculty of the Latvia Univberity Jānis Dzelde studied diagnostics and immunization of tuberculosis. In 1938, "Latvian Veterinary Journal" (*"Latvijas Veterinārais žurnāls"*) published his studies "Tuberculinization and control of bovine tuberculosis" and "Response of calves immunized with BCG to tuberculin". In 1939, J. Dzelde's article "Foot and mouth disease in Latvia" was published.

In conclusion, beginning from 1919, when the core of the UL Faculty of Veterinary Medicine was established, research started in the specialties of veterinary science, such as infectious diseases, surgery, internal non-infectious diseases, veterinary morphology, embryology, pathological morphology, and animal hygiene.

Even though during the early years of the Faculty of Veterinary Medicine there was lack of the most essential facilities for the Departments (not even mentioning space and equipment for research), Latvian veterinary scientists such as Voldemārs Brencēns, Ludvigs Kundziņš, Rūdolfs Grapmanis, Artūrs Vītums, Miķelis Rolle, and others studied and gained knowledge at the most prestigious veterinary schools and institutes in Germany, France, Italy, Denmark, Austria, and elsewhere in Europe.

The years 1945–1964: veterinary research at the Faculty of Veterinary Medicine when it was located in Riga

The time period after the Second World War was marked by large socioeconomic changes in Europe as well as in Latvia, which, without doubt, affected development of the whole Faculty and of the research carried out by its scientists.

The war brought large material losses upon the Faculty. Faculty facilities were partially destroyed, equipment was lost, and large damage was done to the library, museum, and study materials.

In the fall of 1944, the Faculty of Veterinary Medicine of the University of Latvia was incorporated into the Latvia Academy of Agriculture (LAA) as the Veterinary Faculty (VF).

There were changes in the number of the teaching staff and in their scientific qualifications as well. Along with the increase in the number and scientific qualifications of the teaching staff, also the researches started earlier expanded.

Studies in veterinary morphology, embryology, and pathological morphology were continued.

Docent Otto Janovskis studied embryonic development of equine stomach and, based on these studies, defended his dissertation and received scientific degree of the Candidate of Biological Sciences in 1954.

In 1947, Zenta Siliņa (maiden name Šifa) started working at the Department of Anatomy. Later she became a docent and studied development of bovine stomach. In 1962, Z. Siliņa defended her dissertation "Topographical and anatomical structure of bovine stomach during fetal period", for which she received scientific degree of the Candidate of Biological Sciences.

In the 1950s, research projects in physiology and pathologic physiology were undertaken.

Earlier studies in pathological morphology were continued by docent Milda Skudiņa. In 1954, she defended her dissertation "Pathomorphologic lesions in stomach and intestines of horses which died of colic" receiving degree of the Candidate of Veterinary Sciences. In later years, M. Skudiņa studied lesions induced by pasterellosis in pigs, and tuberculosis, while specializing in hygiene and inspection of animal-derived food products as well as in diseases of crayfish, bees and fish. In 1961, M. Skudiņa published her study "Histological morphology and parasites in the stomach and intestines of healthy horses" in the scientific journal of the LAA.

In 1956, Eglons Grapmanis, who at that time was senior lecturer (later – longtime dean of the VF and interim professor), defended his dissertation "Dynamic of salivary, gastric and intestinal gland secretion during disorders of water exchange" for the degree of the Candidate in Veterinary Science.

Research in physiology of digestion of ruminants broadened after Raimonds Daugerts joined the Department of Anatomy and Physiology. R. Daugerts studied the role of the low molecular weight volatile fatty acids in synthesis of milk fat, and the effect of functional processes in the forestomachs of ruminants on the metabolism.

In 1956, R. Daugerts, later interim professor and Vice Rector of Studies at LAA, defended his dissertation for the scientific degree of the Candidate of Biological Sciences – "Change and synthesis of low molecular weight volatile fatty acids in milk fats of ruminants". This research direction was later continued by R. Daugerts' students – docent A. Garančs and P. Keidāns, later professor at the FVM.

In the 1960s, interest in morphological studies increased at the VF. In 1958, Zigmunds Brūveris joined the Department of Anatomy and Physiology, and a few years later, in 1963, became a professor: He defended his dissertation "Development of spinal cord in correlation with development of spine in cows and pigs" for the degree of the Candidate of Biological Sciences. Later, Z. Brūveris changed his scientific interest from the complicated research of CNS to the histological and histochemical bovine liver ontogenesis studies and became one of the leading scientists–hepatologists in the Baltics.

During this period, a very rapid development in clinical sciences took place.

From 1945 to 1964, research work in internal non-infectious diseases was led by professor P. Apinis, but later – by docent and interim professor Zalamans Manevičs.

Zalamans Manevičs, being an excellent teacher and clinician, studied gastric diseases and colics of horses, ketosis and leucosis in cattle, anemia and vitamin A deficiency in pigs, porcine edema disease, and dyspepsia. A great part of study results were included in text books "Diseases of esophagus and forestomach of cows" (1958) and "Metabolic diseases of animals" (1961).

Interim professor Z. Manevičs did some studies together with senior lecturer Edgars Vējiņš, who at that time was writing his dissertation "Acetonemia in cows depending on feeding and husbandry conditions" for obtaining degree of the Candidate of Veterinary Science. Unfortunately, E. Vējiņš was not able to finish this work because of a tragic, premature death.

Research was going on also in the specialty of veterinary science – surgery. Diseases caused by foreign bodies in cows, as well as their surgical treatment were the research interest of Pēteris Leimanis (later – docent). Based on this work, Leimanis defended his dissertation in 1948 and received degree of the Candidate of Veterinary Science.

In later years, P. Leimanis organized artificial insemination of cows and wrote text books "Non-infectious diseases of domestic animals" (1957) and "Artificial insemination of farm animals" (1965).

Research in surgery specialty of the veterinary science was continued with studies of the biological processes involved in wound healing. Since 1955, Ādolfs Jurdžs (later – docent) focused mainly on the healing process of infected wounds and on their treatment. In 1964, A. Jurdžs defended his dissertation "Use of furagvanidine for treatment of infected wounds in farm animals", for which he was awarded degree of the Candidate of Veterinary Science. Docent Ā. Jurdžs was the first in Latvia to start using ultrasound for treatment of surgical diseases.

Orthopedics and ophthalmology, as well as improvement of various surgical methods were the focus of studies done by Džems Širaks (later – docent). In 1955, Dž. Širaks defended his dissertation "Influence of water temperature on production of dairy cows, feed digestibility and clinically measurable physiologic parameters" and received degree of the Candidate of Veterinary Science. Parallel to studies in veterinary surgery, Dž. Širaks studied also the history of veterinary medicine. After his initiative, commemorative plaques and a memorial bas-reflief were made and installed for the outstanding Latvian veterinarians–scientists R. Grapmanis and K. Helmanis. In the textbook "Ocular diseases of domestic animals" (1961), docent Dž. Širaks included the results of his research into veterinary orthopedics and ophthalmology.

After 1947, in the specialty of veterinary science – obstetrics and gynecology (theriogenology) –, significant studies were carried out by Igors Afanasjevs (later – professor at the VF), particularly on etiology, diagnostics and treatment of bovine mastitis. In 1952, I. Afanasjevs defended his dissertation "Use of erythryn and furacylin for treatment of acute mastitis in cows" and received degree of the Candidate of Veterinary Science. He participated in the development of "mastizan", which was widely used for treatment of mastitis and for which I. Afanasjevs received a certificate of authorship (1959).

Development of new medications, using research data from pharmacodynamic studies of Latvian medicinal plants, was the area of active work of docent Jānis Augškalns, the leading researcher in pharmacology. In 1955, J. Augškalns defended his dissertation "Pharmacology of *Erysimumcenexens Roth* cultivated in Latvia SSR" and received degree of the Candidate

of Veterinary Science. In the coming years, docent J. Augškalns studied pharmacological characteristics of essential pine oils and their potential use in veterinary medicine. The medication "Piniols" was developed under his leadership. His knowledge and experience in pharmacy and pharmacology J. Augškalns summarized in publications "Prescriptions" (1959) and "Veterinary pharmacotherapy" (1963).

Between 1945 and 1964, intensive research in the field of animal infectious diseases and parasitology continued at the LAA Veterinary Faculty.

Chicken tuberculosis was studied by senior lecturer Arkādijs Aniščenko. In 1959, he defended his dissertation "Role of calcium and vitamin D in natural resistance of hens against infection with tuberculosis" and received degree of the Candidate of Veterinary Science.

The research in animal tuberculosis was continued by docent Olga Lušņevska. She studied the detection of tuberculosis based on response to allergen and factors that influence expression of intracutaneous reaction. O. Lušņevska defended her dissertation "Influence of year on infection" for the Candidate of Veterinary Sciences degree in 1947; the research results were included in the textbook "Infections and immunity" (1962).

In the postwar period, significant research was done by professor Augusts Kirhenšteins. While being the head of the Department of Hygiene (later – the Department of Epizootology), he published more than 300 articles about the development and structure of bacteria, the immunology, the role of vitamins in daily rations, and the control of infectious diseases. In 1954, A. Kirhenšteins published his book "Problems in microbiology and immunology" (in Russian).

In 1948, studies in infectious diseases were started by Anna Nicmane (later – docent and professor of the VF LAA). In 1953, A. Nicmane defended her dissertation "Cows with subclinical mastitis as infection source for healthy cows in LSSR" and received degree of the Candidate of Veterinary Science. Her future studies mainly were focused on infectious diseases of pigs and on enzootic diseases in neonatal animals. Results of her research were published in the monograph "Infectious diseases of pigs".

In-depth research of fish diseases was done by Līvija Grapmane (later – docent). In 1962, she received degree of the Candidate of Biological Sciences for her dissertation "Fish diseases, their prevention and treatment on fish farms of Latvia SSR".

At the Veterinary Faculty, research in animal hygiene was done by future docent and interim professor Leons Zālītis. He studied the effect of zoohygenic and sanitary procedures on animal productivity, as well as prevention of diseases, optimization of microenvironment, quality of drinking water and possibilities for its improvement, and productivity in correlation with thermoregulation. In 1958, L. Zālītis defended his dissertation for the Candidate of Biological Sciences degree – "Evaluation of dermoelectrometry and dermoreactinometry results in dairy cows during indoor and pasture periods".

Intensive research at the VF LAA continued also in parasitology specialty of veterinary science. In 1945, future docent of the Veterinary Faculty and professor Hermīne Vaivariņa started to study helminth fauna in farm animals in Latvia. In 1950, she defended her dissertation "Helminthoses of farm animals in Latvia SSR" for degree of the Candidate of Veterinary Science.

Under leadership of H. Vaivariņa, studies of helminths and helminthoses in chickens, ducks and geese were started by Velta Paudere (later – docent). In 1961, V. Paudere defended her dissertation "Helminthofauna and most common helminthoses in domestic foul in Latvia SSR"

for degree of the Candidate of Veterinary Science. In the coming years, her studies focused on the control of ruminant lungworm, echinococcosis, and cysticercosis in Latvia.

Also assistant Natālija Aniščenko's research interest was parasitology. In 1953, N. Aniščenko defended her dissertation for the Candidate of Veterinary Science degree – "Pathomorphological changes during experimental hydatidcysticercosis in goat kids and piglets associated with migration, growth and development of parasite larvae".

In 1955, prof. J. Dzelde published his textbook "Hygiene of farm animals".

Veterinary science at the VF LAA from 1965 till renewal of Latvia's independence

In the summer of 1964, both the Veterinary Faculty from Pērnavas street and the dissecting room from Kronvalda boulevard in Riga moved to new facilities in Jelgava.

The teaching staff of VF regularly presented results of their research at scientific and scientifically practical conferences organized by universities and research institutes in other Republics of Soviet Union.

Teaching staff together with technical staff and students of the VF participated in contract research and carried out significant fundamental and applied studies.

Details regarding significant teaching, organizing and administrative work that each of the scientists mentioned in this article devoted to the Faculty, the University (Academy), and Latvia are intentionally omitted as, more or less, this information has already been included in "Biographical encyclopedia of Latvian veterinarians" (Preinbergs, 2004) and in "Higher education in veterinary medicine 1919–2004" (eds P. Keidāns, O. Parčinskis, 2004).

Development in various specialties of veterinary science will be addressed according to the departments of the Veterinary Faculty of LLA where the particular research was done.

At the Department of Anatomy and Physiology, professor Z. Brūveris continued intensive studies in veterinary hepatology. In 1970, he defended his second dissertation "Hepatic morphology and histochemistry during ontogenesis of cattle" in Kijev and received the Doctor of Science degree. Z. Brūveris presented the results of his study in the 9th World Congress of Anatomists in Leningrad (1970). Studies about morphofunctional characteristics of liver in dairy cows were continued under guidance of the professor. His research team was joined by Pārsla Apetjonoka and Jāzeps Rimeicāns (later – docent and associate professor); the latter defended his dissertation "Seasonal changes in morphofunctional characteristics of the liver in dairy cows of large production units in Latvia SSR" in 1982 and received the Candidate of Veterinary Sciences degree. This study describes seasonal morphofunctional changes in the liver of dairy cows who were kept in large dairy complexes and were fed according to the guidelines of the time.

In 1969, Edīte Birģele, who was postgraduate at the VF Department of Anatomy and Physiology, defended her dissertation "Histogenesis and histochemistry of abomasal mucosa in cattle" for the Candidate of Biological Sciences degree.

The second research direction in veterinary morphology at the Department of Anatomy and Physiology was osteology. Miervaldis Pastuhovs, postgraduate at the Department, under leadership of Z. Brūveris completed his study and in 1965 defended his Candidate of Veterinary Science dissertation "Influence of various types of silage on growth and development of skeleton of Latvian Brown cows evaluated by several radiographic parameters". After leaving the Veterinary Faculty, M. Pastuhovs continued his research in osteology and

summarized the obtained results in his second dissertation "Changes in bone structure of cattle during ontogenesis" (scientific advisor was Z. Brūveris); he received Dr.med.vet. degree in 1979.

Intensive studies continued also in physiology of digestion. Docent A. Garančs studied the effect of fermentation processes within forestomachs on metabolism and circulation of nitrogen in ruminants. The results were summarized in his dissertation "Influence of urea, ammonium acetate and ammonium sulphate as feed additives on digestion in rumen and some indicators of metabolism and productivity of ruminants", which A. Garančs defended in 1977 and received degree of the Candidate of Veterinary Sciences.

Studies in digestion physiology in his dissertation summarized also P. Keidāns (later – professor). In 1974, he defended his Candidate of Biological Sciences dissertation "Effect of various ratios of proteins and easily digested carbohydrates on digestion processes in rumen and on some indicators of protein–carbohydrate metabolism in ruminants".

R. Daugerts and A. Garančs with coauthor Dz. Zariņa included results of their long-term studies in digestive physiology of ruminants in textbooks "Experiments and tests in animal physiology" (1977), "Animal physiology" (1978), and "Physiology of lactation" (1985).

In 1984, Viktors Grapmanis (later – docent at the Department of Anatomy and Physiology) defended his Candidate of Veterinary Sciences dissertation "Therapeutical and prophylactic characteristics of ampycillin, gentamycin and levomycetin for colibacillosis in poultry".

In the middle of the 1960s, prevalence of bovine lymphocytic leucosis rapidly increased in Latvia. To study this disease, LAA VF scientists (Z. Manevičs, G. Preinbergs, E. Vējiņš, and O. Parčinskis) cooperated with scientists from the Animal Husbandry and Veterinary Scientific Research Institute of Latvia and from A. Kirhenšteins Institute of Microbiology. Newest conclusions regarding the clinical presentation and laboratory diagnostic methods of bovine leucosis Z. Maņevičs, interim professor of the VF Department of Internal Non-infectious Diseases, included in his book "Clinical diagnosis of internal diseases of farm animals" (1968).

Under guidance of professor Z. Manevičs, VF postgraduate (later – docent) Gunārs Preinbergs completed his Candidate of Veterinary Sciences dissertation "Hematological and biochemical characteristics of cows with untreated leucosis and treated with tiafofamide", which he defended in Tartu in 1972.

In the 1970s–1980s there was a trend towards mass production (mechanization) in agriculture and in the production of animal-derived products. The number of farm animals in production units was increasing, and there was a change in livestock husbandry and feeding. Along with these changes, metabolic diseases increased, which served as basis for setting priorities in the research of the Department of Internal Non-infectious Diseases: bovine ketosis and its biochemical characteristics, diagnostic tests, treatment and prevention (Z. Manevičs, E. Vējiņš, Ļ. Jemeļjanovs, V. Šķicis); dyspepsia of calves, its etiological classification and etiopathogenesis (Z. Maņevičs); diagnosis and prevention of vitamin A deficiency in calves and pigs (Ļ. Jemeļjanovs); improvement in dispanserization of cows, and diagnosis, treatment and prevention of metabolic diseases (Ļ. Jemeļjanovs, L. Leite, A. Jakovskis); and nitrite and nitrate toxicities in pigs and cattle (L. Leite). The results of metabolic problem research in productive animals formed the basis for two dissertations of the Candidate of Veterinary Sciences at this Department: dissertation of Ļevs Jemeļjanovs "Effect of some factors on vitamin A and carotene metabolism and their role in dispanserization of Latvian Brown cows and calves" (1974; scientific advisor Z. Maņevičs), and

dissertation of Līga Leite "Hematological and biochemical changes during nitrate and nitrite toxicities in cattle and swine" (1979; scientific advisor Z. Maņevičs).

The main focus of contract research at the Department was development and clinical evaluation of new veterinary medications (Ļ. Jemeļjanovs – 1970–1990; V. Šķicis – 1984–1987). In collaboration with Experimental Production Laboratory "Sigfarm" and Renal Transplantation Center of P. Stradiņš Clinical Hospital, medication "Holinols" was developed and patented for treatment of ketosis in farm animals (Ļ. Jemeļjanovs, I. Afanasjevs, G. Preinbergs, V. Šķicis, and others – 1980).

Basing on the results of his own studies as well as on studies of the researchers of his Department, Z. Maņēvičs wrote text books: "Internal non-infectious diseases of farm animals" (1980) and "Metabolic diseases and alimentary toxicities in farm animals" (1983).

The extensive experience obtained in pharmacology as well as results of his studies docent J. Augškalns included in two books "Veterinary pharmacology" (1972) and "Poisoning in farm animals" (1975), in which readers are informed how to protect farm animals from poisoning with toxic plants and mineral supplements in LSSR, as well as what to do in cases of poisoning. In 1981, J. Augškalns published his book "Veterinary prescriptions", and in 1990 – methodical guidelines "Prescriptions and pharmaceutical technology".

It was found that in animals with metabolic diseases, their reproductive capacity is reduced, the number of offspring decreases, and the number of infertile animals increases. Studies in this area were done by professor Igors Afanasjevs, chair of the Department of Surgery and Obstetrics. I. Afanasjevs summarized his study results in his second, Doctor of Science, dissertation "Morphological endometrial and biochemical blood characteristics in infertile Latvian Brown cows", which he defended in 1972. I. Afanasjevs' study results are included also in his books "Diseases of reproductive organs in cows" (1969), "Artificial insemination of cows and sheep" (co-author V. Seglenieks; 1972), "Reproductive diseases of cows" (co-author G. Preinbergs; 1982), and "Veterinary obstetrics and gynecology" (1983).

Professor I. Afanasjevs together with collaborators G. Preinbergs and Ļ. Jemeļjanovs developed (and registered with authorship's certificate) medications "mastizan" and iodine oxide, which were widely used for treatment of inflammation in udder and uterus (1967, 1978).

As a result of intensification of farm production, productive life of cows decreased – each year ~30% of cows were culled because of various diseases, including reproductive diseases. On average, only 3–4 calves were obtained from one cow. Additionally, infertility most often was observed in highly productive cows, which caused necessity to develop biotechnology methods such as embryo transplantation. Embryo transplantation was first adopted and implemented in the collective farm "Tērvete" by veterinarians Leons Liepa and Jānis Pīlaps. In collaboration with them, postgraduate Vita Antāne under leadership of professor I. Afanasjevs completed her Candidate of Veterinary Science dissertation "Superovulation and quality and quantity of embryos depending on hormonal status, endometrial and metabolic indicators in donor cows", which she defended in 1990.

In the time period from 1986 till 1990, a scientific/technical program "Development of embryo transplantation methods" was developed at the newly established Embryo Transplantation Laboratory of the VF (in collaboration with the Specialized Construction Office of the State [VSKB] "Rāmava", which provided technical and material support). As part of this program, embryos collected from donor cows were transplanted into recipient cows at the Study and Research farm "Vecauce" and VSKB "Rāmava".

In the 1970s–1980s, in the field of veterinary theriogenology and genetics, oocyte isolation, cultivation and fertilization *in vitro* with subsequent embryo transplantation into recipient cows became increasingly popular. In 1984, docent G. Preinbergs established an oocyte cultivation laboratory at the VF, in which he together with his collaborators (B. Amoliņa, L. Turks, I. Tīrmanis, etc.) carried out contract research for the Ministry of Agriculture "Cultivation of bovine oocytes with subsequent *in vitro* fertilization, embryo cryopreservation and development of transplantation methods" (1987–1990). Since it was essential to provide absolutely clean reagents, wholesome media and hormonal supplements for experimental work with cells, it was necessary to have close collaboration with A. Kirhenšteins Institute of Microbiology, with the State Veterinary Laboratory, as well as with USSR Research Institute of Animal Genetics and Reproduction in St. Petersburg (former Leningrad).

In regards to research in animal reproduction it is important to underscore many scientific contributions of A. Jemeļjanovs, Dr.habil.agr. Dr.vet.med. He received Candidate of Veterinary Sciences degree (after nostrification – Dr. med. vet. degree) for defending dissertation titled "Causes for breeding bull culling in artificial insemination centers" in Vitebsk, Belorushia in 1971. A. Jemeļjanovs received the Doctor of Agricultural Science degree (after nostrification – Dr. habil. agr. degree) for dissertation "Evaluation of breeding bulls based on the resistance of their offspring to diseases" in Saintpetersburg in 1990. Common themes for both dissertations were andrology and pathogenesis. In the latest years A. Jemeļjanovs has lead research that addresed issues regarding the quality of animal-derived food products. He is the true member of Latvian Academy of Sciences (academician). He also is one of the founders of the Latvian Academy of Agricultural and Forestry Sciences, serving for many years as vice president. A. Jemeļjanovs together with co-authors has developed and registered 11 patents. Under his leadership 11 disserations have been defended. For a considerable time period, concurrently with the work in the Faculty of Veterinary Medicine, A. Jemeļjanovs has been the director and chairman of the scientific board of the LLU research institute of Biotechnology and Veterinary Medicine„Sigra".

In the specialty of veterinary surgery, studies continued in ophthalmology and orthopedics (Dž. Širaks) and the results obtained were included in two monographs: "Veterinary orthopedics" (1969) and "Special veterinary surgery" (1985). Docent A. Jurdžs addressed the changes in minerals, microelements and amino acids during healing of wounds in cows. Docent Z. Polītis improved surgical treatment of udder diseases, which he described in his publication "Stenotic diseases of teat duct and milk cystern and their treatment in dairy cows" (1966). Results of his studies Z. Polītis included in his Candidate of Veterinary Sciences dissertation "Diseases of milk excretion system in dairy cows in LSSR", which he defended in 1967. In 1974, Z. Polītis' book "Surgical diseases of udder in cows" was published.

At that time in surgery, several other monographs were published by Dž. Širaks ("Veterinary orthopedics" in 1969, and "Special veterinary surgery" in 1985) and A. Jurdžs ("Trauma in domestic animals" in 1968, "Surgical diseases of domestic animals" in 1972, "General veterinary surgery" in 1976, and "Pathogenetic therapy of animal diseases" in 1976).

Intensive studies continued also in the area of infectious diseases of animals. Professor Anna Nicmane continued her research into infectious diseases of pigs. Her study results formed the basis for her second doctoral dissertation "Epizootology of porcine atrophic rhinitis and its eradication in Latvia SSR", which she defended in 1971 and received the Dr. med.vet. degree.

Studies of mycobacteria as part of the project "Characterization of mycobacteria, occurrence of mycobacterial lesions in people, animals and solution of the problems" were carried out by the postgraduate Edgars Liepiņš (later – docent and associate professor). His research results E. Liepiņš included in his Candidate of Veterinary Science dissertation "Main characteristics of etiology and diagnostics of tuberculosis in pigs in Latvia SSR", which he defended in 1975.

Research work on the development of automated veterinary information processing system by Gundega Mičule also should be mentioned. As a result of this work, G. Mičule defended her Candidate of Veterinary Science dissertation "Analysis of automated information system and its use in planning of preventive and treatment schedules in large dairy units" in 1982.

Research into parasitology was also continued. Studies focused on the effects of parasites on various physiological and biochemical processes in host organisms and on product quality; on the diagnostics of parasitic diseases, epizootology, treatment and prevention; on helminthofauna of wild animals; and on diseases of bees (M. Skudiņa, L. Grapmane, P. Keidāns, and A. Krūklīte).

Veterinary medical research from 1990 till 1999

Starting from 1992, scientific degrees awarded during the USSR period were nostrified as follows: Degree "Candidate of Biological or Veterinary Science" was replaced by "Doctor of Biological or Veterinary Science", and degree "Doctor of Science" was replaced by "Habilitated Doctor of Science". So, scientists with the degree of Candidate of Veterinary Science became Dr.med.vet., but Doctors of Science became Dr.habil.med.vet. (Z. Brūveris, A. Nicmane, I. Afanasjevs, and A. Jemeļjanovs – Dr.habil.med.vet., and E. Birģele – Dr.habil.biol.).

After the renewal of Latvia's independence, there were only slight changes in the research trends of the FVM. Research was no longer limited to production animals but included also studies addressing important health issues of pet animals (mostly dogs).

In the 1990s, veterinary science of FVM had several directions. Firstly, in-depth research was carried out into the morphofunctional processes in various organ systems and into etiopathogenesis of diseases in animals of various species and ages, taking into consideration new technologies in animal husbandry. Secondly, general and specific preventive, diagnostic and treatment methods for infectious diseases in animals were developed and improved, so that they would be suitable for new economic conditions for the 1990s. FVM scientists worked in both research directions according to the specifics of each department. Additionally, a majority of senior scientists repeatedly went for training to related institutions in economically developed Western countries and afterwards, with the new knowledge gained on these visits, evaluated the research carried out within their departments.

At the Department of Anatomy, Dr.habil.med.vet. Z. Brūveris continued to lead research of liver pathology and prevention of liver diseases. Studies of functional morphology indicated that on the basis of drug "Richocel", an effective and original medication (without equivalent anywhere in the world) for treatment of a frequently encountered liver disease – hepatosis – can be developed. The scientists of the Department discovered that the cellulose in "Richocel" inhibits degradation of choline which promotes its transport to the intestinal tract, favoring its absorption. This preparation normalizes carbohydrate and lipid metabolism and decreases hepatic lipidosis. In 1999, J. Rimeicāns defended his dissertation "Problems of hepatosis in dairy cows in Latvia" in veterinary hepatology and receiving the degree of Dr.habil.med.vet.

The second research topic at the Department of Anatomy was study of the effect of various types of housing and barn technologies on the development of skeleton of Latvian Brown calves in

postnatal ontogenesis. Study results were included in A. Mugurevičs' doctoral dissertation "Variation in gross and microstructure of cattle metopodial bones depending on various housing conditions in postnatal ontogenesis and from historic perspective", which he defended in 1997.

At the Department of Physiology, research was directed towards experimental studies in digestive physiology. Using intragastric pH measurement method, which was a new method in veterinary medicine but already widely used in human functional diagnostics, Dr.habil.biol. E. Birģele led studies on the dynamic changes of gastric pH in pigs of various ages. Studies outlined the pH changes in various gastric zones during physiological resting conditions when hydrochloric acid producing fundic glands are inactive (in the morning, when animals are not fed) and after the biggest stimulator of gastric glands – feed consumption (E. Birģele, A. Garančs, I. Keidāne). Studies were done to determine the effect of various types of feed on the secretory function of gastric cardial, fundic and pyloric glands, which in turn determines the pH changes within these zones. Intragastric pH is important in determining activity of gastric enzymes and movement of gastric contents, as well as in regulating separate steps of secretory and motor functions of gastro-duodenal system.

During that period, O. Parčinskis devoted his attention to research of another problem in swine – cardiomyopathy in pigs and sudden death syndrome associated with it. Using morphometric, massometric and volumetric measurements, significant differences were detected in pigs of various ages and with various types of lesions in organs and tissues. This allowed the understanding of the mechanism of death (tanatogenesis) during this pathologic process.

At the Department of Internal Non-infectious Diseases (later – Section), Dr.med.vet. Ļ. Jemeļjanovs continued to study important topics in diagnosis, treatment and prevention of internal non-infectious diseases, giving special attention to diseases of neonatal animals. It is known that neonatal diseases often manifest with non-specific clinical signs, thus making specific diagnosis complicated. In order to determine specific diagnosis, Ļ. Jemeļjanovs recommended a new, complex approach to the dispanserization of calves; for a rational treatment of commonly encountered dehydration in neonatal animals, he recommended a new, previously unused assessment: determination of the degree and type of dehydration, allowing more exact rehydration therapy to be selected.

At the Department of Surgery and Obstetrics (later – Section), scientists led and carried out studies important for the time.

Under leadership of surgeons Dr.med.vet. Z. Polītis and Dr.med.vet. A. Jurdžs, new methods for treatment of traumatic bone and joint injuries in dogs were developed. Study was started to look at hip joint dysplasia in dogs of various breeds and to determine the usefulness of some radiographic parameters for early diagnosis of hip dysplasia (O.Kozinda). Scientists also tested effectiveness of a new biologically active medication for wound treatment and studied hoof diseases of cows kept in various housing conditions and the effect of these diseases on productivity of cows.

At the end of the 1990s, studies were started in a new direction in veterinary medicine in Latvia – veterinary dentistry (A. Ilgažs). Prevalence and types of dental diseases as well as their possible prevention were assessed.

In the area of obstetrics and gynecology, work of professor I. Afanasjevs was continued by his student Dr.med.vet. V. Antāne, who led research in hormonal regulation of reproductive cycle and reproductive capacity. Clinical approbation of new immunocontraceptive medication was done, and its toxicity was assessed. Studies were started to determine udder health in dairy herd utilizing somatic cell count and concentration of lactose in milk samples from bulk tank.

It should be mentioned that assoc.prof. Vita Antāne was a member of the Standing Committee of International Congress on Animal Reproduction for 16 years (1996–2012). In 2012, during the 17th congress of animal theriogenology in Canada, this responsibility was transferred to her student Dr.med.vet. Evija Liepiņa.

In 1993, Laima Liepa (later – docent at FVM) defended her Dr.med.vet. dissertation "Improvement of methods for induction of superovulation for embryo transfer in cows". The work was done at the Latvia State Animal Husbandry and Veterinary Research Institute "Sigra" (scientific supervisor – A. Jemeļjanovs).

In the 1990s, important research at the FVM took place in the field of general and specific prevention and early diagnostics of infectious diseases, in development and improvement of treatment methods, as well as in veterinary legislation.

Dr.habil.med.vet. A. Nicmane, Dr.med.vet. E. Liepiņš, and Dr.med.vet. R. Trubka in collaboration with the State Veterinary Department developed guidelines for prevention and control of infectious diseases in animals, and criteria and rules for assessment of new drugs in veterinary medicine.

Under leadership of Dr.med.vet. P. Keidāns, for the first time in Latvia, coccidiofauna of animals in Latvia was determined and studies of epizootology of coccidiosis were carried out, as well as guidelines for its treatment and prevention were developed. Prevalence of coccidiosis in pigs in various regions in Latvia was analyzed (A. Krūklīte and D. Keidāne), the dynamics of infection in a set time period was studied, and most effective treatment regiments for coccidiosis, balantidiosis and helminthoses were experimentally determined (trichopol together with panacur or himcocide with rintal).

Activities of veterinary scientists at the FVM LLU from 2000 till 2013

Beginning from 2000, when the Departments were reorganized into three Institutes at the Faculty of Veterinary Medicine of the Latvia University of Agriculture (FVM LLU), scientists together with their doctoral, master's and veterinary degree students continued their earlier studies as well as started to address important issues in food and environmental hygiene.

At the Preclinical Institute of FVM, studies in digestive physiology of ruminants during postnatal ontogenesis are continued (principal investigator – E. Birģele; collaborators – Z. Brūveris, A. Ilgaža, and D. Keidāne). Digestive problems in calves remain an important research issue, as shown by extensive studies done by researchers in many countries in recent years. Necessity of such research is underscored by the fact that during the first months of postnatal development of calves, significant morphofunctional, microbial and enzymatic changes occur in the stomach.

Studies at the Preclinical Institute focus on physiological processes that occur in ruminants from the time of their birth till their transition to ruminant status in correlation with their age and type of feed. Correlations between morphofunctional characteristics of the liver, changes in serum biochemistry, morphofunctional state of abomasum, as well as assessment of changes in pH in the forestomach and saliva in newborn calves, in calves fed milk, and in calves in transition period to coarse feed have been explained.

The mechanism of regulation of hydrochloric acid secretion in abomasum in calves during postnatal ontogenesis has been studied. Effects of histamine H_2 receptor and M-cholinoreceptor blockers on HCl secretion in calves of various ages in correlation with feed have been determined. These are important issues because neuro-humoral regulation of secretion in the abomasum largely determines coordinated function of the entire digestive system.

Parts of the above-described studies were included in the dissertation of A. Ilgaža "Functional adaptation of stomach during early postnatal ontogenesis of *Bos Taurus*", which she successfully defended in 2007 (scientific advisor – E. Birģele). Now, assoc.prof. Aija Ilgaža together with her doctoral students A. Ārne and L. Otzule continues her studies of digestive physiology in ruminants studying effect of biotheurapeutical additives on morphofunctional development of digestive tract in calves and goat kids during postnatal ontogenesis.

Researchers of the FMV Preclinical Institute have been recently involved in morphofunctional studies of productive animals that are less traditional in Latvia – ostriches (A. Mugurēvičs, I. Dūrītis, L. Mancēviča) and goats (E. Birģele, D. Keidāne, A. Ilgaža).

Regarding ostriches, it should be emphasized that they are becoming popular in Latvia (and in Europe) because of the consumer demand for meat with lower fat and cholesterol content. It turns out that ostrich chicks in Latvia and in Europe have high mortality – only 50% of ostrich chicks reach age of four months. Therefore it is very important to study the unique morphological features of the digestive tract in ostriches addressing changes in the various compartments during ontogenesis, especially since data in the published literature is very scant. Part of the results were included in the dissertation of I. Dūrītis (scientific advisor – A. Mugurēvičs) "Morphofunctional characterization of the stomach and small intestine of the ostrich (Struthio camelus var.domesticus) from day 38 of embryonic development to the age of 60 days.", which he defended in 2011 and received his Dr.med.vet. degree. Study of ostriches from four months till 12 months of age under supervision of A. Mugurēvičs is continuing with doctoral student L. Mancēviča.

In Latvia, goat farming is also becoming more popular, therefore studies that support high quality and high yield of goat products are needed. Nematode infections of the digestive tract of goats are among main causes for poor body condition and decreased productivity. Studies in recent years indicate that goats in Latvia suffer from a large variety of parasitic diseases (P. Keidāns, D. Keidāne, A. Krūklīte), of which the most common problem is strongyles of digestive tract. What is the effect of these parasites on the morphofunctional state of stomach in goats during various periods of postnatal ontogenesis, how it is reflected in serum chemistry parameters, and how it affects the quality of dairy and meat products – these are questions currently addressed by scientists of the Preclinical Institute (E. Birģele, D. Keidāne, A. Ilgaža).

Functional state of the stomach of goats of various ages depending on their feeding and parasites of digestive tract was the subject of D. Keidāne's dissertation "Dynamics of intraruminal and intraabomasal pH in normal goats and in goats infected with *Ostertagia circumcincta*" (scientific advisor – E. Birģele), which she defended in 2010 and received her Dr.med.vet. degree.

Knowing that in the gastrointestinal tract of people and animals commonly encountered are helicobacteria, many of which are pathogenic and able to cause various gastric, intestinal and hepatic lesions (gastric ulcers, gastroenteritis, etc.), the question was raised whether goats may concurrently with strongyles also have helicobacteria (it is presumed that source of these bacteria is contaminated feed or contamination with feces). And what about *Helicobacter pylori* in the digestive tract of dogs? With the goal to gain experience in veterinary pathology and also to learn newest diagnostic methods for *Helicobacter* spp. detection, Mag.med.vet. Dace Bērziņa went to South Korea in 2005 – to the Faculty of Veterinary Medicine of the Chonbuk National University. The results of her study about *Helicobacter* spp. in cardial, fundic and pyloric glands of gastric mucosa of domestic dogs were included in D. Bērziņa's dissertation "Helicobacteria in the mucosa

of canine stomach and morphofunctional state of the stomach", which she defended in 2010 and received the degree of Dr.med.vet. (scientific supervisor – E. Birģele).

Significant studies at the Preclinical Institute have been carried out in electrocardiophysiology. This is a new research direction in veterinary science in Latvia (G. Avdoško, D. Upeniece, E. Birģele). Cardiac electrophysiological parameters and their differences were studied in dogs in correlation with dog's breed, age, and heart rate. For the first time, 10 ECG leads were used and their practical use in veterinary medicine was evaluated. In 2004, D. Upeniece defended her dissertation "Cardiac electrophysiological parameters in Cocker spaniels, Rottweilers, and German Shepherd dogs", for which she received her Dr.med.vet. degree (scientificsupervisor– E. Birģele).

Further, it was important to determine the effect of most commonly used anesthesia medications in dogs on the functional parameters of the dog's heart. With this, studies in veterinary anesthesiology in Latvia were started – both in experimental settings using *in vitro* isolated frog heart in order to determine effects of premedication and anesthesia drugs on heart rate and force of muscle contraction and *in vivo* studies in dogs (G. Avdoško). These studies showed that premedication drug atropine sulfate together with acepromasine malleate in heart causes a negative chronotropic effect, but general anesthesia medications ketamine hydrochloride and diazepam cause an opposite effect – heart rate increases, therefore the chronotropic effect is positive.

These issues were included in the dissertation of G. Avdoško "Changes in cardiac biopotential during anesthesia in dogs", which he defended in 2007 receiving his Dr.med.vet. degree (scientific advisor – E. Birģele).

Work in veterinary anesthesiology was continued by L. Kovaļčuka, who studied the effects of premedication and general anesthesia medications on the functional state of eyes in dogs as determined by changes in intraocular pressure and horizontal diameter of pupil induced by mydriatic drugs atropine sulfate, fenylephrine and tropicamide and by general anesthesia. In 2011, L. Kovaļčuka defended her dissertation "Changes in functional parameters in eyes induced by mydriatic, premedication and general anesthesia medications in dogs" (scientific advisor – E. Birģele) and received her Dr.med.vet. degree; with this, research in veterinary ophthalmology in Latvia was started. It should be emphasized that L. Kovaļčuka closely collaborated with ophthalmology professor D. Williams from the Department of Veterinary Medicine, the University of Cambridge; professor D. Williams in many ways supported and promoted studies of L. Kovaļčuka.

Intensive studies in veterinary pathology started in 2009, when associate professor Ilze Matise-Van Houtana, who had received PhD degree and board certification in veterinary patholoy in USA, joined the FVM. Under leadership of I. Matise-Van Houtana, the project funded by Latvian Science Council "Stem cell therapy for type 1 diabetes: a new potential for insulin dependency treatment" was carried out. I. Matise-Van Houtana together with her doctoral students Inese Bērziņa and Linda Kokoreviča is studying tick-borne diseases in dogs in Latvia and has initiated studies in veterinary oncology.

In the scientific activities of the Clinical Institute of FVM during the period 2000–2013, several directions can be recognized. Very fruitful and perspective has become collaboration with professor Dr.habil.sc.ing. V. Kanceviča from Riga Technical University addressing orthopedic and vascular disease problems in human medicine and in small animal clinics. Preclinical testing of blood vessel prosthesis made from composite materials (aortic prosthesis) and patches for hernia repair in experimental animals is carried out under leadership of Dr.med.vet. A. Auzāns (A. Mālniece, O. Kozinda). It is well known that one of the main problems in human medicine is high morbidity

and mortality due to cardiovascular diseases. Medical doctors have shown that it is possible to partially replace the damaged segment of artery with synthetic prosthesis providing that it meets stringent requirements: longevity, elasticity, non-toxicity, etc. Therefore preclinical safety testing of new, high quality prostheses will remain very important and necessary.

The same can be said about experimental studies of scientists of the Clinical Institute regarding testing of hernia repair patches made from special composite fibers in rabbits at Riga Technical University as well as testing of woven prosthesis for repair of cranial crutiate ligaments in dogs (A. Auzāns, O. Kozinda).

At the Clinical Institute, professor Dr.med.vet., Dr.habil.agr. A. Jemeļjanovs[1] and Dr.med.vet. V. Antāne together with their doctoral students continue studies of reproductive problems in farm and pet animals.

From 2002 to 2004, Dr.med.vet. V. Antāne was the coordinator in Latvia for international project "Farm animal reproduction-reducing infectious diseases and conserving local genetic resources". This was a joint project among the Faculties of Veterinary Medicine of all three Baltic countries and the Center of Reproductive Biology of Swedish University of Agricultural Sciences. In the continuation of the project "Animal farming in transition – the role of animal reproduction" (2005–2008), Agricultural Academy of Belorussia and Institute of Agriculture Business from St. Petersburg also joined the first four participating institutions. This international collaboration was continued as part of the program "Visby" from 2010 to 2012.

Under leadership of Dr.med.vet. V. Antāne, problems in udder health were studied in correlation with changes in immunoglobulins in milk and blood during pasture period of dairy cows (I. Kociņa and Ļ. Jemeļjanovs). It was important to determine if during this time there is change in humoral and cellular immunity which would characterize udder health in general. Authors studied concentration of immunoglobulins (IgG, IgM, IgA) in milk and blood of cows when their housing and feeding conditions changed and determined correlation between Ig concentration in milk, blood, and somatic cell count. Using these criteria, various medications for treatment of subclinical mastitis were evaluated. These studies showed that somatic cell count, lactose concentration, and changes in immunological parameters allow objective assessment of udder health in cows. Part of these results were included in the dissertation of I. Kociņa "Dynamic changes in immunoglobulins A, G, M, lactoferrin and somatic cell count in correlation with seasonal housing and presence of pathogens in the udder" (scientific advisor – V. Antāne), which she defended in 2011, receiving her Dr.med.vet. degree. At the same time, doctoral student E. Liepiņa in collaboration with Ypäjä Equine College of Finland and under supervision of associate professor V. Antāne completed her dissertation "Morphological and functional characteristics of endometrium after artificial insemination of mares depending on degree of cervical opening", which she defended also in 2011 and received her Dr.med.vet. degree.

Metabolic studies in dairy cows, mainly during the period before and after parturition when cows suffer from energy deficiency, also are being continued at the Clinical Institute. Associate professor Dr.med.vet. L. Liepa together with her doctoral student M. Viduža has started studies on the diagnostics for subclinical ruminal acidosis and the role of probiotics in prevention of this disease.

[1] Scientific activities of professor A. Jemeļjanovs and of the Research institute "Sigra" directed by him are included in a separate paragraph.

There is an opinion that future farm animal production will be based on precision technologies. Precision-based technologies in dairy farming have been developed and successfully used in many countries. In reality this means use of computerized dairy herd management systems and use of milking robots.

There is a question about the effect of milking robots on the udder health. This is addressed by further studies in udder health and milk quality, using milking robots (V. Antāne in collaboration with I. Lūsis, lecturer of the FVM Institute of Food and Environmental Hygiene, and with A. Lauris, lecturer of the LLU Technical Faculty).

At the same time, Clinical Institute in collaboration with JSC "Grindeks" has intitated the project "Effect of medication GX on the quality of boar semen and testicular morphology". Goal of this study is to develop a new medication for improvement of the quality of boar and bull semen (L. Liepa, Z. Brūveris, V. Antāne, A. Auzāns, etc.). Improvements have also been made in ultrasound-guided testicular biopsy in boars (L. Liepa, I. Dūrītis, M. Mangale).

Under guidance of professor A. Jemeļjanovs, doctoral student Ilga Šematoviča studied microbial flora of uterus as well as endometrial changes in dairy cows after calving during physiological and delayed uterine involution. For the first time in Latvia, in collaboration with professor M. Pilmane from the Laboratory of Morphology of the Institute of Anatomy and Anthropology of the Riga Stradiņš University, factors that are involved in inflammation, growth and degradation were studied using immunohistochemical methods. Results of the study were included in the dissertation of I. Šematoviča "Morphological and biochemical blood values, microflora of uterus and endometrial changes during postpartum period in dairy cows", which she defended in 2010, receiving Dr. med. vet. degree.

Studies in small animal dentistry are also continuing. One of the most commonly encountered diseases in oral cavity of dogs is periodontitis. Various stages of this disease are studied in correlation with bacterial populations in the oral cavity and in duodenum (A. Ilgažs). Parts of this study are included in the dissertation of A. Ilgažs "Periodontitis in dogs, its etiopathogenesis and changes in bacterial spectrum in oral cavity and duodenum", which is currently in preparation for its defense (scientific advisors – Z. Polītis, E. Birģele).

In 2009, O. Kozinda defended his dissertation "Utilization of some radiomorphometric parameters for diagnosis of canine hip dysplasia" (scientific advisors – Z. Polītis and Z. Brūveris).

Studies at the Food and Environmental Hygiene Institute in 2000–2013 were directed in two closely related blocks: endoparasitic diseases and risk assessment of zoonotic parasitic diseases in Latvia (P. Keidāns, A. Krūklīte, D. Keidāne), and epidemiology and control of animal infectious diseases and epidemiology foodborne infections (E. Liepiņš, R. Trubka, A. Valdovska, A. Bērziņš, M. Terentjeva).

In collaboration with the LLU Research Institute of Biotechnology and Veterinary medicine "Sigra" and with the Laboratory of Morphology of the Institute of Anatomy and Anthropology of Riga Stradiņš University, doctoral student and later associate professor Anda Valdovska of the FVM carried out studies that formed a basis for her dissertation "Lesions associated with mold infection in mink affected by Aleutian disease", which she defended in 2008 (scientific advisors – A. Jemeļjanovs and M. Pilmane).

Regarding studies in zoonotic endoparasitic diseases, the main research focus has been on trichinellosis and toxoplasmosis. These studies have described the most commonly encountered species of *trichinella* in domestic pigs and wild animals, have outlined the risk factors, and have

determined the epidemiological situation in the recent years in Latvia. It was determined that 28.9% of foxes were infected with trichinella. Identification of larvae of *thichinella* was done in Copenhagen – at the Center of Experimental Parasitology of Denmark. The authors have shown that in Latvia there are three species of *Trichinella* that are encountered most commonly – *T. spiralis*, *T. native*, and *T. britovi*and – all of which are human pathogens. It has been concluded that the best results for detection of *trichinella* are achieved with digestion method using artificial gastric juice.

Regarding toxoplasmosis, it has been reported that it is a widespread parasitic disease of domestic animals in Latvia. With latex agglutination test, toxoplasma infection was detected in 30.4% of pigs, in 44% of cats, in 46.6% of dogs, in 45% of sheep, and in 40% of goats. Most common risk factors identified were: contamination of the environment by cats shedding toxoplasma oocysts; long survival of oocysts in the environment (one year or more); consumption of food products (meat, milk and products from animals that are potentially infected) that are not sufficiently thermally processed; increase in rodent and homeless cat populations; and failure to comply with precautionary measures during contact with animals (P. Keidāns and A. Krūklīte). Broader epidemiologic studies are needed for a complete analysis of risk factors.

In recent years, studies in food hygiene have intensified at the FVM Food and Environmental Hygiene Institute. Biological hazards from consumption of contaminated milk and dairy products have been analyzed (E. Liepiņš). It has been found that enterotoxin-producing *Staphylococcus aureus* can be detected in milk and dairy products in Latvia, presenting a problem that needs to be addressed (R. Joffe). Studies have shown that 77% of *S. aureus* isolates from mastitis cases in dairy cows can produce enterotoxins, most commonly, enterotoxin A. Studies of this subject are very important because part of the risk of staphylococcal enterotoxemia comes from dairy cows with subclinical mastitis and from cows whose milk does not enter the market directly.

Important role in the development of food hygiene research played professor Hannu Korkeala from University of Helsinki and professor Magne Yndestad from Norwegian School of Veterinary Sciences who hosted and trained several Latvian researchers in Finland and Norway over last 15 years. Research in epidemiology of foodborne infections also is directed towards studies of meat product contamination with pathogenic bacteria *Listeria monocytogenes* (A. Bērziņš) and *Yersinia* spp. (M. Terentjeva, A. Bērziņš, E. Liepiņš).

It is known that spread of these organisms is largely facilitated by movement of raw materials into processing. Moreover, persistent contamination in the meat processing environment and equipment was studied over 10 years. Researchers' attention was focused on detecting *L. monocytogenes* in various cold-smoked meat products and on determining factors that are associated with *L. monocytogenes* contamination during cold-smoked meat processing in several meat processing plants in Latvia. In collaboration with the Faculty of Veterinary Medicine of the University of Helsinki, molecular characterization of *L. monocytogenes* isolates with the pulsed-field gel electrophoresis method was applied. Study results were included in Aivars Bērziņš' academic dissertation "Molecular epidemiology and heat resistance of *Listeria monocytogenes* in meat products and meat-processing plants and listeriosis in Latvia", which he defended at the Faculty of Veterinary Medicine of the University of Helsinki in 2010.

Presence of pathogenic bacteria of Yersinia genus was studied in pig carcasses, by-products, and tonsils (M. Terentjeva, A. Bērziņš, E. Liepiņš – 2006, 2008). It was determined that pathogenic Yersinia *Y.enterocolitica* 4/0:3 and *Y.pseudotuberculosis* are present in tonsils of pigs and that prevalence of *Y. enterocolitica* 4/0:3 is significantly higher than prevalence of

Y.pseudotuberculosis. Further studies focused on comparison of pathogenic Yersinia in tonsils, carcasses and plucks of pigs in slaughterhouses in Latvia. Results of these studies were included in the dissertation of M. Terentjeva, which she defended in 2011 receiving Dr.med.vet. degree.

In collaboration with associate professor Mati Roasto from the Department of Food Hygiene of the Institute of Veterinary Medicine and Animal Science of Estonian University of Life Sciences, doctoral student K. Kovaļenko from the FVM Food and Environmental Hygiene Institute addressed the problem about presence of thermophilic campylobacteria in broiler meat in Latvia. Results of the study are summarized in K. Kovaļenko's dissertation, which is currently under review process.

To some extent, studies evaluating effectiveness of oral vaccination for control of rabies in the period 1991–2011 are completed (E. Oļševskis). Results of the study are included in the dissertation of E. Oļševskis "Eradication of rabies in Latvia using oral vaccination of foxes (*Vulpesvulpes*) and raccoon dogs (*Nyctereutesprocyonoides*)", which is currently under review process.

Important research at the FVM has been done in fish diseases (R. Medne). When fish are raised in artificial conditions, parasites and pathogenic microorganisms are brought with water from rivers. In natural conditions, these organisms would not induce diseases but in conditions with high fish density and stress (cleaning of feeders, feed changes, sorting of fish, etc.), microbial virulence increases and causes increased fish morbidity. Fin necrosis in salmon is one of diseases that affects salmon population and its renewal and maintenance. R. Medne studied epidemiology of fin necrosis in salmon, determining the effect of etiologic factors on health of salmon fry. Results of the study are summarized in her dissertation "Clinical signs of fin necrosis in salmon and characterization of its etiological factors", which she defended in 2011. Thus, Dr.med.vet. R. Medne has become one of the leading researchers in the field of fish diseases.

It also should be mentioned that the FVM associate professors V. Antāne and A. Valdovska and docents O. Kozinda and D. Keidāne responded to the call for highly qualified guest lecturers from National Agrarian University of Kazakhstan in Almaty. As a result of this collaboration, LLU signed an agreement with National Agrarian University of Kazakhstan, and now the above-mentioned FVM scientists are serving as scientific advisors for doctoral students of this university.

Conclusion

In essence, research at the LLU FVM from the time it was established has been geared towards its overall growth and increase in number of researchers, as well as towards development of separate specialties of veterinary science – veterinary morphology, pathologic morphology, internal non-infectious diseases, physiology, surgery, infectious diseases, as well as hygiene and inspection of animal-derived nutrients (nowadays called food hygiene).

After renewal of Latvian independence, activities of FVM researchers were essential to meet three objectives outlined for science:

1) to renew scientific and academic personnel (to increase the number of doctoral students and to motivate doctoral students to successfully finish the studies);
2) to develop science at universities;
3) to develop applied scientific research by increasing its share in science.

We consider that these objectives have been partially fulfilled. Over the past 10 years, 14 students have completed their doctoral studies at the FVM, receiving the degree of Dr.med.vet., 10 of whom are working as academic staff at the Faculty. Additionally, three other doctoral students have nearly completed their dissertations.

At the same time, it is very important for FVM scientists to expand international cooperation in science, as well as to continue previous collaborations with scientific institutions in Latvia with the goal to achieve increase in the quality of scientific research and to publish research results in international peer-reviewed scientific journals included in the Web of Science data base.

Future research directions of FVM, apparently, will be included in four blocks:

1) development of scientific framework for production of high-quality, safe and healthy food products of animal origin;
2) etiopathogenetic problems, prevention and treatment of common non-infectious diseases in animals;
3) epidemiology, diagnostics, and development of the treatment and prevention methods for infectious diseases of animals, especially zoonotic diseases, prevalent in Latvia;
4) functional processes in small animals (pet animals), pathogenic mechanisms, and prevention of individual organ dysfunction.

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Cooperation between Latvia University of Agriculture and Faculty of Veterinary Medicine in the University of Helsinki

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Abstract. Cooperation between Latvia University of Agriculture and the Veterinary Faculty of the University of Helsinki has been active and fruitful after the disintegration of the Soviet Union. Visits by teachers, students and administrative persons have been the foundation for cooperation. The European Association of Establishments for Veterinary Education and Baltic and Nordic Forestry, Veterinary and Agricultural University Networks BOVA and NOVA UN have been important and stimulating organisations in promoting the cooperation. Significant progress has taken place both in the curriculum and in the postgraduate programmes during the last twenty years.

Introduction

Academic agricultural science celebrates its 150th anniversary in Latvia in 2013. In Finland, agricultural and forestry education on the university level started in 1908 in the University of Helsinki. The College of Veterinary Medicine was founded in 1945, and the veterinary college was merged to the University of Helsinki in 1995. Today, the Faculty of Agriculture and Forestry and the Faculty of Veterinary Medicine are among the eleven faculties in the University of Helsinki (founded in 1640). Both faculties are located in the Viikki Campus, which is one of the largest loci of biosciences in Europe.

In this review, cooperation and development of sciences related to agricultural science, especially veterinary medicine, over the last twenty-five years will be described in brief. During the time before the Second World War, Finnish agricultural scientists actively visited the Baltic countries, as agriculture was more developed on the large manors in Estonia and in Latvia than at the relatively small family farms in Finland. After the Second World War, contacts between scientists were difficult for political reasons, but after the disintegration of the Soviet Union, contacts again developed quickly and vigorously. Cooperation has taken place between the Latvia University of Agriculture (LLU) and University of Helsinki, especially in their faculties of agriculture and forestry and veterinary medicine. Some scientific contacts have also taken place between the state veterinary laboratories (or corresponding institutions), but these will not been described here.

The activities described here span three deans of the Veterinary Faculty of the University of Helsinki, namely Professor Ilkka Alitalo (also the former Rector of the College of Veterinary Medicine in Helsinki), the undersigned Professor Hannu Saloniemi, and the current dean Professor Antti Sukura.

The first years of the new cooperation

Rector of the College of Veterinary Medicine in Helsinki, Professor Ilkka Alitalo visited Jelgava in winter 1991 to get a feel of the veterinary studies in Latvia. He gave a lecture concerning the

study plan of veterinary medicine in Helsinki. The time was ripe for the development of study programmes and for planning new facilities in all Baltic countries.

Professor Alitalo visited Jelgava several times, giving lectures and organizing visits of teachers and graduate students to Helsinki and to Jelgava. At the end of the 1990s, University of Helsinki decided to move veterinary education from the Hämeentie mini-campus to the new buildings in the Viikki Campus. In Hämeentie, there was a cremation furnace or oven for pathological and microbiological waste. This was not allowed to move to Viikki, and Professor Alitalo negotiated its transport to Jelgava. I don't know the later history of this furnace, but hopefully it has been used further. – A small detail about Professor Alitalo's first visit: He had with him a young Estonian veterinarian Mait Klaassen, who acted later twice as chairman of BOVA Rectors' Board!

European networks as a frame of cooperation between LLU and University of Helsinki

The European Association of Establishments for Veterinary Education EAEVE was founded in 1988. The mission of EAEVE is to evaluate, promote and further develop the quality and standards of veterinary medical establishments and their teaching. The Veterinary School in Helsinki was an active member of EAEVE from the beginning. Soon after the disintegration of the Soviet Union, rector Alitalo proposed to the general assembly of EAEVE that the veterinary schools in Tartu, Jelgava and Kaunas should get a membership in the association. That decision was taken unanimously. EAEVE guidelines and evaluations have been important stimuli to the development and benchmarking of study programmes and scientific cooperation.

The Tempus project of 1998–2001 is a good example of cooperation inside a European network. Veterinary schools from Jelgava, Hannover and Helsinki worked together for ensuring that the veterinary curriculum in Jelgava integrates the basic and clinical science concepts in order to produce professional competence equal to European standards. Curriculum visits to Helsinki and Hannover were made by Professor A. Mugurevics and Mr. O Kozinda in 1999, and evaluation of the draft curriculum in spring 2000 was made by Professor Alitalo and Professor Hackbath from Hannover. Five courses were updated, and two new courses were developed. Main reporters of the curriculum workshop in October 2000 were dean Mugurevics, Professor Alitalo and Professor Steinlechner (Hannover). Three students and nine teachers visited Hannover Vet School and also three students and nine teachers visited Helsinki Vet School during this project. About half of the disciplines and subjects of Jelgava curriculum were covered during these visits. Computers, textbooks, CD-ROM programs, and demonstration and laboratory equipment were purchased to departments, clinics and the library in Jelgava during this project. The co-ordinator Gunars Petersons was for a good reason very pleased about the result.

As dean of Faculty of Veterinary Medicine in Helsinki, I myself participated in the evaluation and accreditation visit in Jelgava in April 2001.

Rectors and deans from seven veterinary schools (Copenhagen, Helsinki, Jelgava, Kaunas, Oslo, Tartu, and Uppsala) had a meeting in Jelgava in September 2002. These schools form a local Nordic-Baltic group in EAEVE. The aim of the meeting was to strengthen the group's common policy in EAEVE, and also to further develop common elective courses in basic veterinary education. I was happy to see some nice progress in Jelgava Vet School during the meeting.

In April 2010, Dean Gunars Petersons invited Vice Dean Ülle Jaakma from Tartu and myself to Jelgava for discussion of questions raised by the Jelgava veterinary faculty's EAEVE evaluation. Serious discussions with professors and younger scientists showed economic and other difficulties in meeting the EAEVE's criteria. My impression was that information from other "sister universities" helped veterinary faculty in Jelgava to find the answers to these questions.

Latvia's Council of Higher Education organized the European Social Fund program "Evaluations of Higher Education Study programmes and Proposals for Improvements of Quality" in the Latvia Agricultural University in January 2012. I was honoured to be a member in the evaluation group chaired by Professor in Forestry, Dr. Romualdas Deltuvasis from Vilnius, Lithuania. Other members were Professor Endla Reintam from Tartu and local representatives Baiba Rotberga, Litita Pundina, and Janis Kungs. One week's visit to the different faculties and institutions complemented with comprehensive written information gave us an excellent view to LLU. The final report included many positive comments and also some proposals for further development of education in LLU.

Baltic-Nordic cooperation

During the last two decades, a significant part of the educational and scientific cooperation has taken place as Baltic-Nordic cooperation. The Nordic Forestry, Veterinary and Agricultural University Network (NOVA UN) was founded in 1995 as a platform between the universities in Denmark, Finland, Norway, and Sweden. The corresponding BOVA University Network was formally established in December 1995 in Kaunas, Lithuania, between Estonia, Latvia and Lithuania. Initially, cooperation activities were carried out through the NOVA-BA programme for cooperation between the Nordic (NOVA) and the Baltic agricultural universities (BOVA). As a consequence, the NOVA-BA cooperation scheme was approved, and in the year 1996 a Letter of Intent for further collaboration was signed in Tartu, Estonia. The primary activity of NOVA-BA programme was the organisation of short MSc courses at the BOVA universities in 1996–2000. BOVA has also promoted establishment of professional contacts between the academic staffs of its universities.

In October 1999, the Rectors of BOVA and NOVA met again to review the progress on the cooperation and to sign another agreement. The Rectors concluded that NOVA-BA yielded good results, as confirmed by positive evaluations by participating students and teachers as well as an external expert. One of the greatest values lies in the creation of a strong platform for future cooperation in the form of established personal professional networks. However, a major deficiency in NOVA-BA activity was the complete dependence on external financing, namely by the Nordic Council of Ministers. Little effort was made to find other sources of funding, and NOVA-BA faced a sharp decline in activity in 2001 when support from the Nordic Council of Ministers ceased.

Responsible representatives of NOVA-BOVA recognised the need for a new agreement with strengthened institutional capacities on the BOVA side. It was no longer a question of "help" from the Nordic side, but both NOVA and BOVA universities worked together as well-matched partners. In this situation, the NOVA side succeeded in getting a grant from the K&A Wallenberg foundation for the project "Development of Nordic-Baltic academic cooperation in Forestry, Veterinary Medicine and Agriculture". The grant was used until the end of 2004.

Starting in 2005, BOVA is defined as a persistent network having well developed and functioning administrative structures and clearly defined objectives, tasks and activities, and being supported by its own internal funding. The first BOVA Strategy was developed during 2005 and was approved at the beginning of 2006 by the BOVA Rectors' Board for the period 2006–2009.

Nowadays BOVA continues its operation offering activities for students, PhD students and teaching staff based on both internal and external funds. The initiation and realisation of joint projects has become an essential task for further development.

The NOVA University Network has over all these years been the major partner in many activities and projects. Rector Juris Skujans from the Latvia University of Agriculture acted as Chairman of BOVA Rectors' Board during the years 2007-2009, and Professor Antti Sukura from the University of Helsinki is the current Chairman in the NOVA Board.

Several cooperation meetings have been organized between BOVA and NOVA, and scientific courses and PhD student exchange have taken place. An important step forward has been the easy contacts between university administrators and teachers on the field of basic education and postgraduate training.

One important and productive network was the 'Nordic-Baltic-NW-Russian network for the promoting of veterinary postgraduate training'. This network was chaired actively by Professor Arvo Viltrop from Estonia. The kick-off meeting was in Tallinn in November 2005. Dean Gunars Petersons from Jelgava and the undersigned as the dean from Helsinki had several fruitful meetings during this networking. The network organized several scientific courses financed by the Nordic Council of Ministers through the Nordplus Neighbour programme.

As a result of these international projects, the Netherlands, Germany and Finland were the most popular countries among Latvian veterinary students in their student exchange programmes in the middle of last decade.

One of the newest co-operative activities will be the BOVA Intensive Master Course in small animal oncology. It will be organised by Latvia University of Agriculture in August 5–9, 2013. Teaching team includes lecturers from both Latvia and Finland.

Personal contacts are the basis of cooperation

The deans from Helsinki have visited Jelgava several times, and they have always been welcome. Many teachers and researchers have visited Jelgava and Helsinki, and have made personal contacts with their foreign colleagues. For example, several clinical veterinarians from Jelgava visited Professor Marjatta Snellman in the Department of Diagnostic Imaging after the lecture by Professor Snelmann in Jelgava, and veterinarian Aivars Bērzinš came to the Department of Food and Environmental Hygiene to make his doctoral studies under the supervision of Professor Hannu Korkeala who had also visited Jelgava earlier. Aivars Bērzinš defended his PhD thesis in Helsinki in November 2010. The title of the thesis was "Molecular epidemiology and heat resistance of *Listeria monocytogenes* in meat products and meat-processing plants and listeriosis in Latvia". Doctor Bērzinš has actively developed the scientific cooperation between Jelgava and Helsinki. His effort can be seen also in the Erasmus Intensive Programme "Veterinary Public Health and Emerging Zoonotic Diseases" (http://www.bova-university.org/projects/erasmus-ip-vphealth.html). This course will be given in Jelgava in August 25 – September 7, 2013.

Conclusions

Cooperation is productive and progressive only if all partners are committed to working for common goals. It is also important that partners find definite benefits to their counterparts and to themselves. Cooperation between Latvia Agricultural University and University of Helsinki has been productive and progressive. I have had the pleasure to meet many enthusiastic people in Jelgava and in other places over the last twenty years. They have worked hard to develop their home institutions. I am sure that active intercourse both between Jelgava and Helsinki and together with other partners in Europe and worldwide will continue progressively and productively also in the future.

Acknowledgements

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Appendix

Feedback from the Latvian exchange students:

'I really enjoyed the time in Equine Clinic. As my practice was during the summer I didn't meet a lot of Finnish students during the practice. Really helpful were the clinic staff and the Finnish exchange students from Estonia and Denmark. During the practise most of the time every Finnish speaking doctor spoke English so the language wasn't a problem (if there was too much of Finnish we always could ask to translate). I am satisfied with my time in Helsinki, I saw so many interesting clinical cases and met a lot of nice people.

The clinical teachers always are really encouraging. No one criticized when I didn't get the right answer; the most important was to train to think logic and try to give opinion. At Helsinki Univ, there are more practical teachings. Lectures are very well structured and planned.

I would recommend to go to Equine Clinic in summer because there is a lot to do during that time of year. Also there are not so many students so it is more possible to have hands-on practise. It is nice to know before going in which veterinary medicine field you want to specialize in because 3 months is minimal time to learn as much as possible in it.

Well, get ready for major uptake of information if you go to the Equine Hospital (that is due to the fact that we practically lack any teachings in equine medicine in Latvia). Be active, ask many questions.

Don't worry before going to Helsinki Clinic. If there is any problem there always be someone who can help. And if your choice is to go to Equine Clinic go for it (but try to go in summer). You won't regret it.

I want to thank you for such a great opportunity to study in your university!!'

'Why did you choose the University of Helsinki? : Two my course mates were in this university last year and they enjoyed their stay in this university, and my coordinator also advised me to choose this university.'

'Would you recommend the University of Helsinki to other students? : Yes!!! It's worth going to this university because the way of teaching differs so much, and I wish I could study in this university for a longer period!'

Dimensions of Scientific Research in the Field of Water Management and Environmental Engineering, 1951–2012
Zinātnisko pētījumu virzieni un rezultāti ūdenssaimniecībā un vides inženierzinātnē, 1951–2012

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Abstract. The impact of human activity on the biosphere has caused a global environmental problems related to the natural resources and risks to ecological health such as soil and water pollution that calls for new solutions to help sustaining the development of agriculture, use and protection of water resources. This review article begins by recalling the historical and project context (land reclamation, hydrology, hydrotechnical structures, subsurface irrigation, polders and waste water management), from which research work in the Faculty of Rural Engineering has started in the 1950s. Few most important research achievements and researchers are mentioned in this review article. Nowadays research field deals with some of the core issues and approaches currently faced by the departments of the Faculty, such as monitoring of agricultural run-off, environmental risk assessment, climate change impact evaluation, water quality modelling, and waste water treatment. It could be emphasized that understanding the complex interactions between the use of land for agricultural production and water quality is essential in promoting the sustainable water management in agriculture and healthy environment.
Key words: Agriculture and environment, water quality, water resources, modelling.

Introduction

The Faculty of Land Reclamation of LLU was founded in 1947. The purpose was to contribute to the realization of the objectives of development of modern agricultural practice in Latvia. The Department of Land Reclamation of Latvia Agricultural Academy was founded in the year 1951. Therefore, it was essential that besides education also the scientific research work started. Up to the historical changes in the 1990s, most important research fields of the Department were:

- agricultural and forest drainage;
- subsurface drainage for irrigation;
- application of wastewater and slurry for irrigation.

After the breakdown of the former political and economical system in 1990/1991, Latvia, like other Central and East European states, went through dramatic changes not only in the agricultural (Jansons, 1996; Stalnacke *et al*., 1999; Jansons *et al*., 2003; Vagstad *et al*., 2002) but also in other sectors of society. Higher education system and research programmes were transformed to meet Western standards.

After these changes, the Department of Land Reclamation was reorganized into the Department of Environmental Management in the year 1993, and, two years later, in 1995, into the Department

of Environmental Engineering and Water Management. Among the most urgent topics currently put to the scientists of the Department, are the following:

- monitoring and assessment of non-point source and point source (large animal farms) pollution from agriculture;
- assessment of the measures to mitigate agricultural pollution to the coastal and marine environment;
- watershed modeling.

An important factor in institutional strengthening, research capacity building and providing opportunity significantly upgrade the technical capacities for agri-environmental research that is essential for implementation of national and international commitments in environmental control undertaken by the government, was international cooperation in research projects described in Table 1. As can be seen, the main cooperation partners of the Department in agri-environmental research projects were scientists from Sweden (Swedish University of Agricultural Sciences), Norway (Jordforsk/Bioforsk), and Denmark (Danish Agricultural Advisory Center). Cooperation and transfer of knowledge and equipment enhanced the capacities of the Department to design and implement the water monitoring programs so that it was also suitable and attractive for research and educational purposes (Vagstad *et al*., 2001; Deelstra *et al*., 2004).

Moreover, it was of great importance that a monitoring programme similar to the existing ones in the Nordic countries (e.g. Norway and Sweden) was implemented and specifically aimed at assessing the impact of agriculture on the surface water quality in Latvia. A detailed description of monitoring network, research methods and technologies can be found in articles presented by Jansons (1998), Jansons *et al*. (1999, 2002, 2007), Deelstra *et al*. (1996, 2004), and Vagstad *et al*. (2004).

In addition, it should be noted that scientists of the Department have been involved in the implementation of a relatively large number of national research projects. Most active project leaders/managers were prof. P. Busmanis, prof. V. Jansons, prof. A. Ziverts and prof. R. Sudars.

This paper summarizes historical development of the research in the Department of Environmental Engineering and Water Management (former Department of Land Reclamation and the Department of Hydrotechnical Structures of the Faculty of Rural Engineering) and provides some perspective on the attempts to cope with environmental consequences of agricultural production. Every human activity has, and always has had, an impact to the environment. This also corresponds to agriculture. Development of production systems has resulted in intensification, specialization and concentration of the agricultural production. Latvia is situated in a humid and moderately mild climatic region where rainfall exceeds evaporation, resulting in run-off and percolation losses from the soil during spring and autumn. The annual precipitation in Latvia is 550–750 mm per year (in extremely wet years – up to 1100 mm), evapotranspiration is 420…500 mm that results in the run-off of 150…300 mm per year.

Drainage research

The soils in Latvia are imperfectly to poorly drained. About 50% of the annual runoff is generated from snowmelt in spring, but 30% from rainfall events. Most of the agricultural soil needs subsurface drainage during wet periods in spring and autumn. During vegetation period, drainage should provide trafficability when field operations are necessary. As a result of these environmental conditions, the soil drainage is an important precondition for agriculture and therefore is an urgent need for research in that field.

Table 1

Main international scientific projects of the Department of Environmental Engineering and Water Management

Project and project leader in Latvia	Project partners	Year
Baltic Sea Environmental Programme, Project: Agricultural Runoff Management Study in Estonia and Latvia (P. Busmanis)	SLU and JTI, Sweden	1993
BAAP (Baltic Sea Agricultural Action Programme) BEAROP project, Phase I. (P. Busmanis)	SLU and JTI, Sweden	1993–1997
BAAP (Baltic Sea Agricultural Action Programme) (P. Busmanis)	Swedish Farmers federation	1993–1997
Drainage Basin and Load of the Gulf of Riga, sub-project: Soil and nutrient loss from small catchment; sub-project: Nutrient losses from agricultural areas with high livestock densities in Latvia (V. Jansons)	Jordforsk, Norway	1993–1997
Baltic Sea Experiment. BALTEX project (A. Ziverts)	M. Plank institute and GKSS	1997–2002
Development of a Code of Good Agricultural Practices, Republic of Latvia (P. Busmanis)	Denmark, DAAC	1998–1999
Environmental monitoring in agriculture. Nordic – Baltic Cooperative (V. Jansons)	Jordforsk, Norway	1997– 2000
BAAP (Baltic Sea Agricultural Action Programme) BEAROP project. Phase II (P. Busmanis)	SLU and JTI, Sweden	2000– 2002
Baltic Sea Regional Project (Component 2, sub-task: Monitoring and assessment) (V. Jansons)	WB & GEF (HELCOM)	2004–2007
Joint Baltic Sea Research Programme (BONUS), RECOCA (Reduction of Baltic Sea Nutrient Inputs and Cost Allocation within the Baltic Sea Catchments) project (V. Jansons)	Stockholm University, Baltic Nest Institute	2009–2011

However, in the 1950s, assessment of the construction work quality and performance of the existing land reclamation systems was an important research task (Eriņš, 1958). In order to facilitate the improvement of the design and construction projects, scale of the topographical maps for drainage design was changed from 1:5000 to 1:2000. Another focus area of the research was related to the construction of drainage tiles, outlets and manholes. For simplicity of design calculations, the graphical method for assessment of discharge capacity of drainage pipes was introduced. It was decided that the minimal slopes for collectors (size of the tile pipes: 12.5 and 15 cm) could be decreased to 0.05%. Research results and experience was documented in recommendations for the design of agricultural drainage (Eriņš, 1966).

The researchers also studied the effect of drainage in forest land. Inventory of forest drainage covered 20 000 ha of forest land. Results of the inventory illustrate the importance of maintenance of drainage channels. Assessment of forest channels suggested that they should be renovated

every 12–20 years. Research on stability of channel banks, main reasons of deformations, peat subsidence and silting of channel bed was carried out by J. Odins (Odiņš, 1972). As the most suitable shape of the cross section for forest channels, the combined trapezium-parabolic shape was recommended. It was found that this type of cross section reduced the transport of sediments by 20–44%, and land area used under channels was decreased by 4.8–14.3%. Research results concerning drainage of forests were published in a monograph (Odiņš, 1971), which was the first comprehensive publication in this field in Latvia.

In the 1960s, research on hydrology of the agricultural drainage started. Researchers developed methods to optimize drainage system designs. Studies of soil water balance, water table elevation was used to determine drain depth and spacing required to optimize drainage performance. In the 1960s, construction of large-size (80–100 ha) drainage systems became popular. After large-scale drainage works had started, P. Sviklis studied economical aspects of drainage. Construction of large systems in the 1970s and replacement of drainage channels with pipes provided better conditions for agricultural production and reduced maintenance costs (Sviklis, 1984, 1988). Research results were used to predict the performance of drainage systems and the effects of drainage design on yields and profits. Additional research was needed to test the relationships and/or to develop new solutions in drainage hydrology for optimum tile drain depths and surface run-off management. Drainage design coefficients using long-term data series, site and drainage parameters, and regional weather conditions were developed. Results were compared with similar research data on hydrology of large systems in Estonia and Lithuania (Sviklis, 1984).

Hydrology

As researchers developed methods to optimize design of hydrotechnical structures, the new research objectives appeared concerning the environmental impacts of structures on minimal water discharge. In rivers with lack of data, minimal water discharge could be calculated with two major methods: a) using maps of hydrological parameters; b) using empirical formulas (Sarma, 1960, 1990; Sarma *et al*., 1972, 1974). Prof. B. Sarma developed empirical formulas for the calculation of minimum river discharge ($l\ s^{-1}\ km^2$) for the vegetation season with return period once in 5, 10, and 25 years.

Hydrology of the local water storage reservoirs was studied by J. Barbars (Barbars, 1968). Water run-off in large river basins significantly differs from the run-off in small catchments. Local run-off collection and use for agricultural purposes have become more important due to the construction of fish ponds. Main water sources for ponds consist of snow, rain, and spring flood. A simple calculation formula was recommended (Barbars, 1968):

$$y = 0.78\ x - 9.4,$$

where y – spring flood run-off, mm;
x – water content in the snow.

Prof. A. Ziverts performed statistical analysis of the long-term stream flow data for 80 hydrological monitoring stations in 1951–1994 (Zīverts, 1995). Results could be used for calculations of the hydrological parameters for rivers where flow measurements are not available. That has high

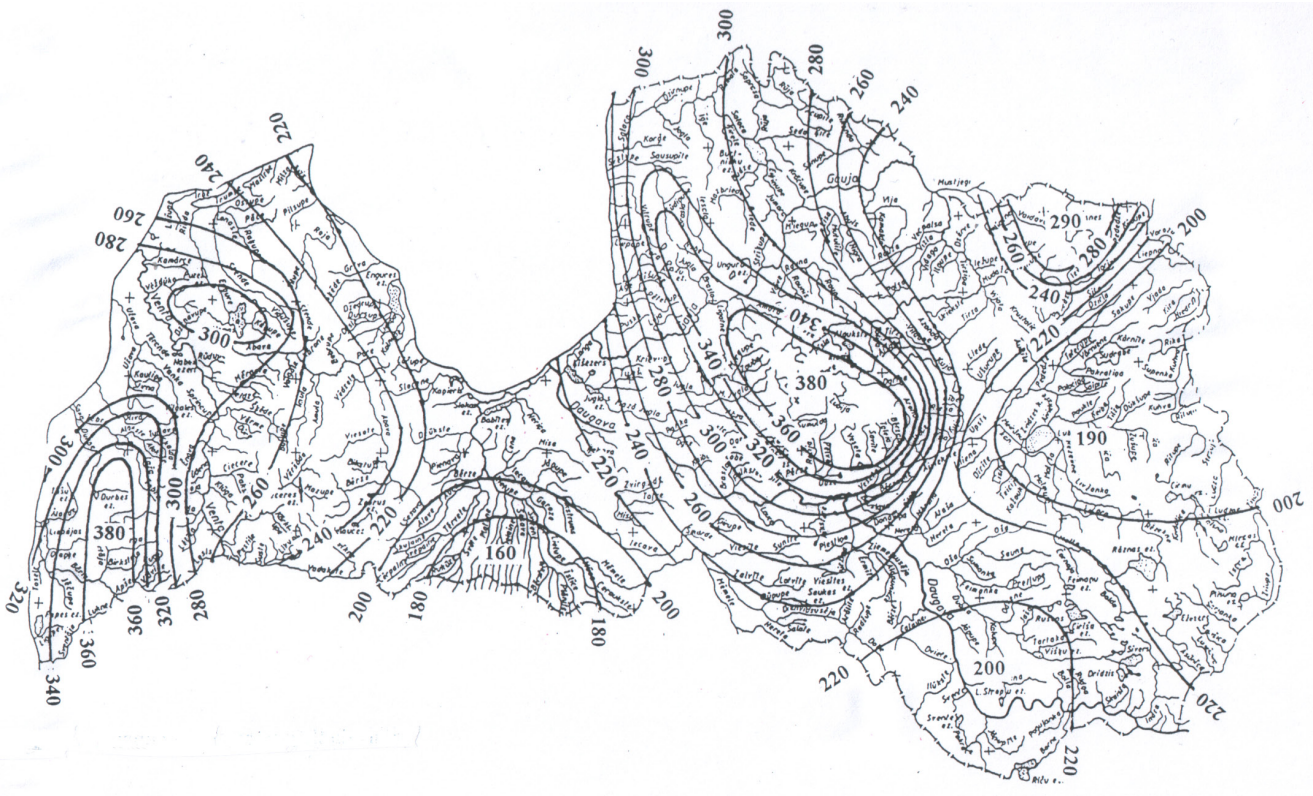

Fig. 1. Annual average run-off in Latvia, mm year^{-1}.

practical value for design of drainage systems, roads, bridges and small power stations and has been included in construction standards of Latvia. Moreover, formulas for calculation of spring flood maximal discharge and summer minimal discharges for four geomorphologic zones in Latvia were elaborated (Zīverts, 1995, 2000).

Prof. A. Ziverts prepared several maps with interpolation diagrams for determination of:

- maximum spring flood coefficient with return period 100 years;
- spring flood run-off with return period 100 years, mm;
- summer minimum run-off generation climatic parameter;
- geomorphological conditions for the territory of Latvia;
- maximum summer–autumn flood run-off , m^3 s^{-1} km^2;
- average summer run-off, l s^{-1} km^2;
- drainage coefficient for arable land and pastures, l s^{-1} ha^{-1};
- daily peak values of storm water, l s^{-1} ha^{-1};
- annual average run-off , mm year^{-1} (Fig. 1).

The average run-off map could be used for evaluation of power production capacity of small hydropower stations. The assessment of 293 power station sites was performed by K. Silke and J. Strubergs (Siļķe *et al*., 1999).

Polders and subsurface irrigation

Part of agricultural land in Latvia cannot be drained with conventional methods by gravity flow. In order to promote the development of agriculture and flood protection in these areas with specific natural constraints, pumped drainage (polders) is only one solution to achieve good status

in flood protection. Main polder construction areas are located around the Babite, Liepaja, Pape, and Burtnieka lakes, and alluvial areas along the Lielupe and Barta rivers.

First polder (1 320 ha) in Latvia (Babite lake) was constructed in 1936; the largest Vecberze polder (5 050 ha) was constructed in 1966. Total area of polders in Latvia today is 46 000 ha with 43 pump stations that drain 35 000 ha of agricultural land. Besides agricultural land, the 13 pump stations near Lubana lake, and the Uzava, Tome and Ogre rivers provide flood protection for 73 000 ha of rural settlements.

First research on polder drainage was started by T. Kadrevica in 1959. Main research objectives were optimum pumping schedule, drainage coefficient, and volume of pumped water (Kadreviča *et al*., 1976).

Although the methods to assess the impact of humid conditions of soils on agricultural production are well studied, the impacts of dry weather have received less attention. During vegetation season, water deficiency is very common for soils of Latvia. Sprinkler irrigation systems are expensive and always are not economically sustainable for all agricultural crops. Therefore use of the conventional drainage pipe network for subirrigation, which is a water table management system for control of the elevation of a water table to provide water necessary for crop growth, could be economically more viable.

Application of dual purpose drainage systems was studied by V. Labrencis during 1970–1980 (Labrencis *et al*., 1976). Advanced water table management systems typically involve the installation of specific water table control structures. For water level control, slide gates and manholes for adjustment of a water table could be used. A water table could be adjusted for specific needs of crops: drainage to irrigation, or irrigation to drainage modes. Research results showed that the subirrigation systems could provide increase in yield by 65–105%.

Subirrigation of perennial grass in dry weather conditions has a 3–5-year money return period of investments (Labrencis *et al*., 1976, 1982).

Waste water and water supply

If waste water effluents are discharged into streams or the sea, the organic material causes growth of algae with a consequent fall in the level of dissolved oxygen and other parameters of water quality. Application of the waste water in agriculture for irrigation could be the source of increase in the yield and an efficient water protection measure. Moreover, irrigation with waste water could increase the yield, thus covering construction and maintenance costs of wastewater treatment systems. First research projects in that field started in 1968. Reuse of reclaimed municipal and industrial wastewater in agriculture became one of the most important research fields of the Department, which was headed by professor O. Sauka (Bušmanis, 1973; Tilgalis, 1982; Jansons, 1993).

Determination of irrigation water requirements requires a measurement or estimate of the soil moisture deficiency. Application rate 2400 $m^3\,ha^{-1}$ (six water applications) was recommended for wet years. Seasonal water requirements of up to the 3200 $m^3\,ha^{-1}$ (eight applications) in dry years, in addition to crop water needs, may also include waste water used for additional plant nutrient application. For better protection of water courses, winter storage was recommended (Tilgalis, 1982; Jansons, 1993). Economical efficiency of wastewater use for irrigation was evaluated (Bušmanis, 1973; Jansons, 1993). The yield of perennial grass was increased by 111–118%. The results indicate that after 10 days bacterial pollution of perennial grass was the same as in control

plots without irrigation. Wastewater retention in soil was: NH_4^+ – 72%, PO_4^{3-} – 91%, and BOD_5 – 86% (Tilgalis, 1982).

Several research projects were performed in the field of water supply and sewage treatment. In the 1960s, at the Department of Hydrotechnical Structures (project leader prof. A. Lasis), mathematical equations were developed for calculation of the looped network of water supply lines with computer. Moreover, mentioned above methods were successfully used for design work of water supply network in Riga and Daugavpils considering renovation of the network.

In the 1930s, prof. V. Skards performed an experimental work to find out friction losses for filtration flow in the sand. The findings of this study were approximated for both turbulent and laminar flows. Further research activities of prof. V. Skards were related to the water supply and wastewater treatment. Broad knowledge and practical experience in that field has led to the publishing of the monograph focused on the design of water supply and sewage treatment problems (Skārds, 1970). Last activities of the applied research in this field were done in Riga. The research-based proposals for improvement of the lake Baltezers water extraction system, increase in the yield of groundwater wells, and removal of iron and manganese were prepared (Tilgalis *et al*., 2002). The equation for calculation of specific discharge of unconfined wells in sandy aquifers was developed (Juhna, 2005):

$$Q = \pi\ k\ D\ l,\ m^3\ s^{-1}\ m^{-1},$$

where k – coefficient of percolation, m s^{-1};
D – size of filter pipe, m;
l – length of filter pipe, m.

Assessment of the sewerage system of the Riga city was performed. The main objective of this study was to investigate the impact of effects of extreme weather conditions. The research results indicated that main factor causing extreme loads is stormwater. Combined sewer system in Riga yearly collects 39.12 mill. m^3 of sanitary wastewater flow, 10 mill. m^3 of industrial, and 3.6 mill. m^3 of stormwater flow. During heavy precipitation, several streets have been flooded. The main reason of the high flow is the large surface areas covered with an impermeable layer. The findings of this study (Tilgalis *et al*., 2002) suggest that extremes of run-off value (with different return period) can be calculated (Tilgalis *et al*., 2011):

$$Q_{max} = 0.13\ a\ F\ \psi\ k,\ m^3\ s^{-1},$$

where a – precipitation during wet season, mm;
F – catchment area, ha;
ψ – flow rate coefficient derived from surface characteristics;
k – coefficient depending on the return period of calculation.

Hydrotechnical structures

Hydrotechnical structures are an important part of drainage projects and inland fish farms. In the early 1960s, assessment of safety and stability of fish pond banks and earth dams was performed. Main reasons such as wind and impact of waves of deformations were determined (Rozentāls, 1964). Evaluation of advantages of banks with low side slopes was compared with

banks covered with riprap layer. Construction of low side slopes in large fish ponds was most efficient technical and economical alternative. In that type of water reservoirs, average height of waves could be 0.5–0.6 m. Due to wave erosion, soil particles with size <0.05 mm are washed away. Therefore research results recommended bank side slope for sand 1:12 … 1:15; for sandy loam – 1:8 ... 1:10; for peat – 1:12 ... 1:15. G. Rozentals and J. Zodzins performed an assessment of the stability of overflow culverts in earth dams (Rozentāls *et al*., 1976).

Impact of agriculture on inland water quality

Farmers use chemical fertilizers, manure and other organic materials, and/or crop rotations to replace nutrients withdrawn from the soil during production of agricultural crops (Busmanis *et al*., 2001). Without replacement the soil with nutrients, crop yields or quality would decline in most cases (Haraldsen *et al*., 2001). Primary nutrients for crop growth and development include nitrogen, phosphorus, and potassium, but other macro- and micronutrients are also important. If improperly applied, fertilizers can leach into groundwater or drain into surface water (Vagstad *et al*., 2000a, 2000b; Busmanis *et al*., 2001; Deelstra *et al*., 2009a). Nutrients in surface water can cause eutrophication, oxygen depletion, fish kills, and reduction in recreation opportunities (Bechmann *et al*., 2004). High nitrate levels in drinking water also have adverse human health effects. In all countries of Northern Europe, agriculture is estimated to be responsible for the greatest contribution of phosphorus and nitrogen to coastal waters (Vagstad *et al*., 2001).

Both the EU Nitrates Directive (ND) and the Water Framework Directive (WFD) require that Latvia like all the Member States control the impact of agriculture on the surface and groundwater (Jansons *et al*., 2005). When assessing water quality, it should be considered whether all the territory of Latvia or only part of it, with the highest impact of agriculture measured in terms of high nitrate content (≥50 mg L^{-1}) or eutrophication phenomena, should be designated as nitrate vulnerable zones (NVZs). In addition, the risk that in the near future freshwater bodies or marine waters may contain more than 50 mg L^{-1} nitrates (11.3 mg L^{-1} NO_3-N) or become euthropic if actions in agriculture are not taken, also is a relevant aspect for designation of the NVZs. The risk assessment performed in the Department using GIS tools was based on the data on soil and groundwater media, run-off, potential erosion risk, agricultural activities, such as agricultural land and arable land use, animal density, soil drainage, and application of fertilizers (Jansons *et al*., 2005).

HELCOM recall (HELCOM Baltic Sea Action Plan, 2007) that countries should apply harmonised principles and monitoring methods for quantifying non-point losses throughout the sea catchment area in order to obtain comparable and reliable estimates on the waterborne inputs from both point sources and non-point sources entering into the Baltic Sea. In addition, climate change calls for a more effective environmental policy to protect the water resources of the Baltic Sea.

The net effect of agricultural loading to the Baltic Sea can not be easily predicted using nutrient leaching models in combination with runoff models (Ziverts, Jauja, 1999) and river transport models. The predictive capacity to simulate riverine nutrient fluxes as a function of changes in human activities is facilitated by the nested modeling approach addressing nutrient fluxes from farm scale over regional scale addressing type river basins with characteristic land use patterns in the various Baltic Sea water districts up to river basin scale. Since a substantial share of the anthropogenic phosphorus and nitrogen load origins from agricultural land, there is a need for new innovative approaches in modelling to identify and implement the most cost-effective countermeasures on a regional and local scale.

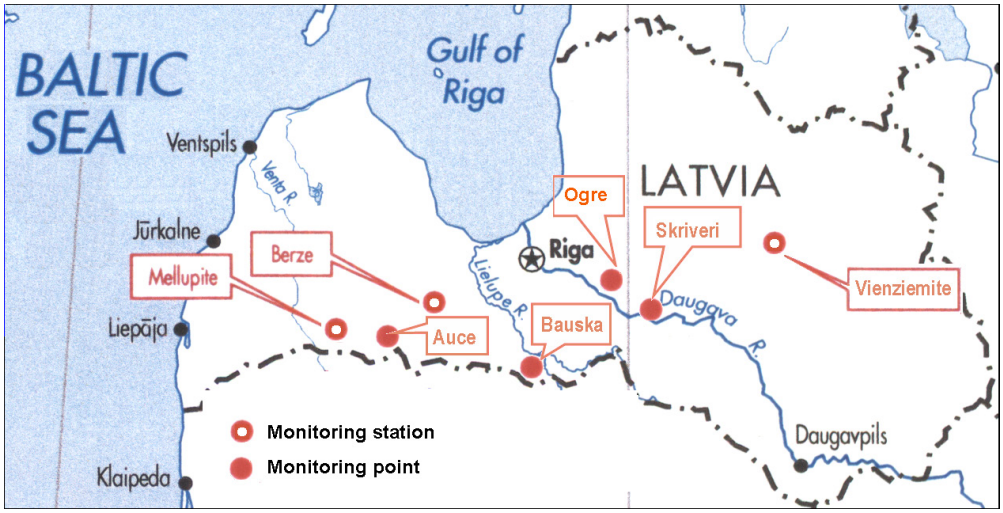

Fig. 2. Agricultural run-off monitoring stations and monitoring points in Latvia.

Monitoring of agricultural run-off

The environmental assessment of representative small watersheds and farms started at selected locations in Latvia. Catchments and demonstration activities were selected to respond to regional differences and to farming intensity. Measurement of leaching and runoff losses of the nitrogen and phosphorus started in several agricultural catchments in the year 1994. The main objective was to quantify losses of nutrients to surface waters and groundwater from agricultural sources. Lack of reliable monitoring data for the estimation of agricultural pollution sources was a common problem in post-Soviet countries, including Latvia. Designs of the monitoring system have been coordinated with the Nordic institutions to ensure the comparability of the data sets and quality assurance measures. For these reasons, it was also important that the applied measurement methods/equipment and procedures are sufficiently advanced to comply with international scientific standards and knowledge/technology transfer from Nordic countries included training in operation/maintenance of monitoring stations, equipped with data loggers and automatic flow proportional sampling. In order to assess agricultural pollution, diffuse source monitoring programmes in Latvia were implemented in three monitoring stations (Berze, Mellupite, and Vienziemite small agricultural catchments) with ordinary agricultural practice as well as in three drainage fields within these catchments (Fig. 2.) In addition, a specific monitoring programme was established in three monitoring points (Vecauce, Ogre, and Bauska catchments) representing large pig farms as point pollution sources, with high rates of animal manure (slurry) application (Sudars *et al*., 2005). A description of monitoring sites is presented by Jansons *et al*. (2002, 2007).

Non-point source agricultural pollution

Figs 3 and 4 provide information on temporal and spatial trends of nutrient run-off from monitoring sites. The variations in nutrient run-off are considerable. The lowest non-point source losses were measured at the Vienziemite monitoring site, where the share of arable land within the catchment was 4–5% during 1994–2008. The highest diffuse source nutrient losses occurred in the Berze site, and exceeded by far the losses in Vienziemite (Jansons *et al*., 2002). In Mellupite catchment, where agricultural land use might be considered as moderately intensive for Latvian conditions, average nitrogen losses were about 10.5 kg N ha^{-1} annually. The lowest losses measured

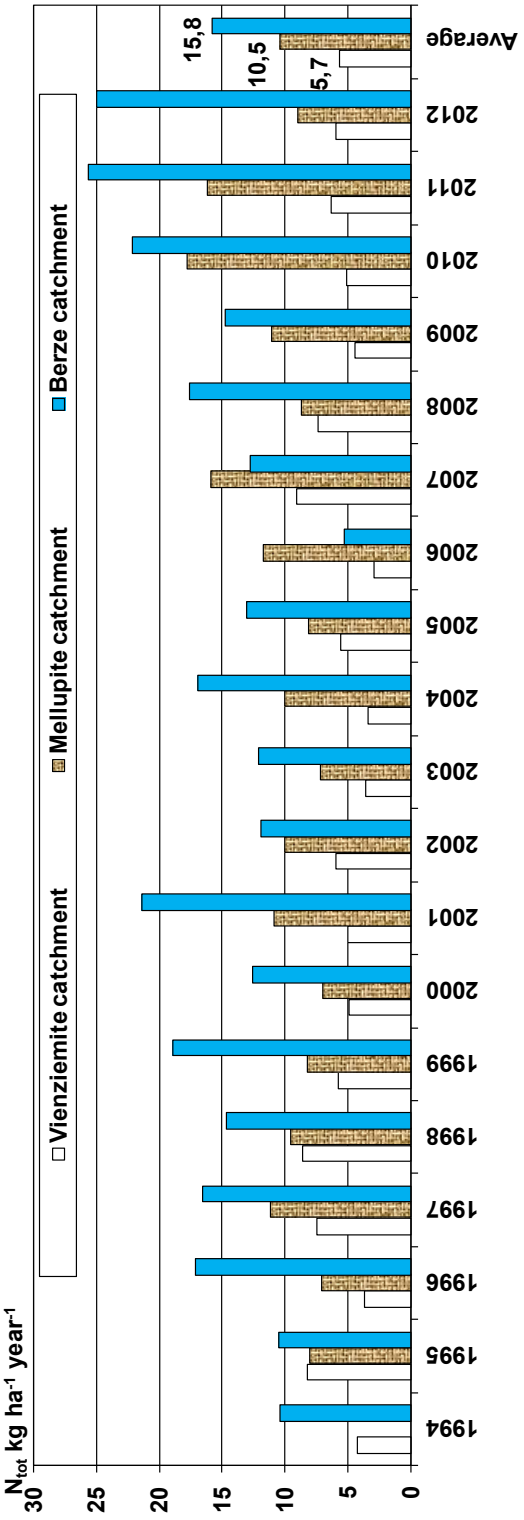

Fig. 3. Nitrogen run-off from small catchments.

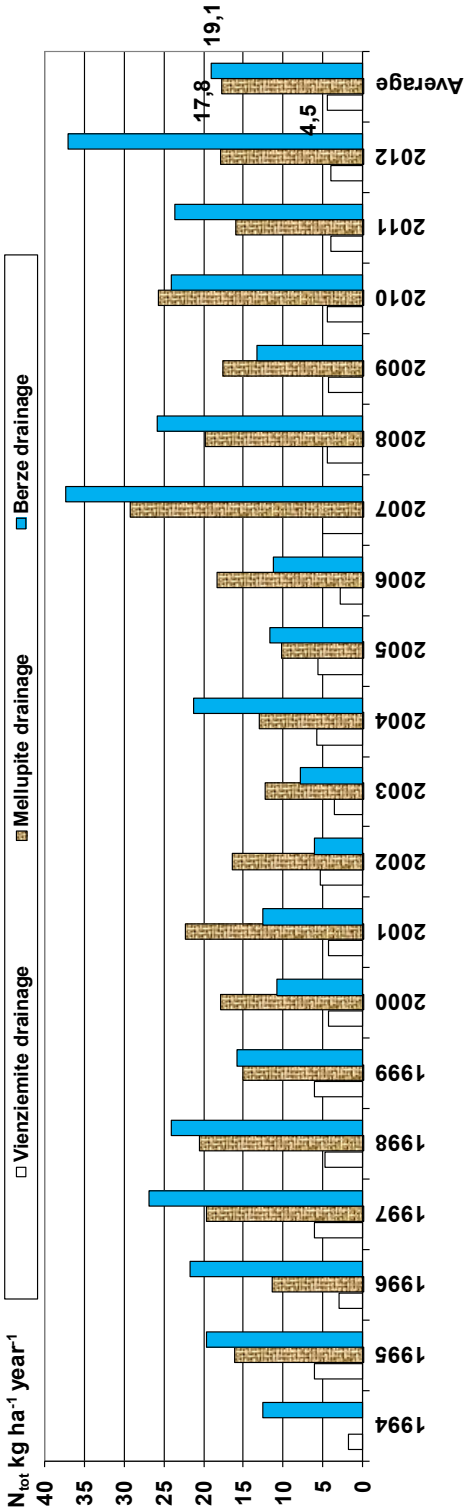

Fig. 4. Nitrogen run-off from drainage fields.

on catchments' scale were 1.8 kg N ha^{-1} and 0.03 kg P ha^{-1} annually in Vienziemīte, while the largest losses in Berze were 25.6 N and 0.52 kg P ha^{-1} annually, respectively.

Generally, it seems that nitrogen loads are higher from field drainage systems compared to the small catchment scale (Figs 3 and 4). At the same time, phosphorus run-off was higher on the small catchment scale.

The diffuse source nutrient losses in the Berze and Mellupite small catchments appear to be low as compared to the recorded losses under similar conditions in the Nordic countries (e.g. Norway and Sweden). Nitrogen losses ranged from 15 to 70 kg ha^{-1} per year in eight small catchments in Norway and Sweden during 1994–1997 (Vagstad *et al*., 2001); average measured nitrogen runoff was 30 kg N ha^{-1} per $year^{-1}$. These losses were approximately two times higher than average losses (15.8 kg N ha^{-1} per year) from Berze small catchment, thus indicating differences in leaching regimes and agricultural practices between areas in Latvia and in Nordic countries.

One important factor may be the difference in fertilizer applications. In Latvian catchments during 1994–2011, average nitrogen application per ha of agricultural land was 4–15 kg ha^{-1} annually in the Vienziemite catchment, 13–70 kg ha^{-1} – in the Mellupite catchment, and 20-120 kg ha^{-1} – in the Berze catchment. Although the average applications are low, some fields within the Berze catchment received 160 kg N ha^{-1} annually.

Another reason for the observed differences in N losses may be different hydrological regimes (Deelstra *et al*., 2005, 2009b), leading to longer water residence time and therefore higher nutrient retention in Latvian catchments.

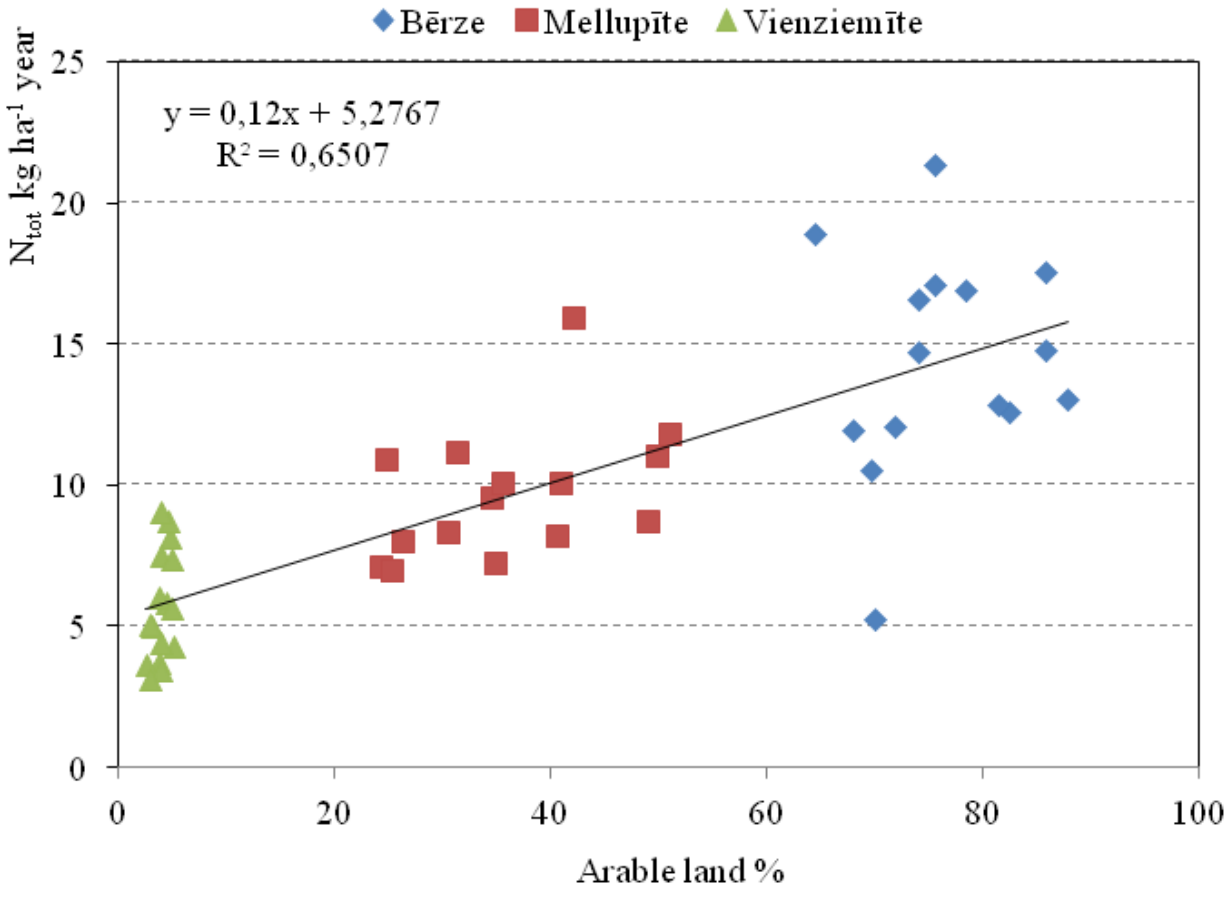

Fig. 5. Nitrogen run-off in relation to area of arable crops in small catchments (1995–2009).

The correlation test between the share of arable land and nitrate contents in the run-off was tried on the small catchment and drainage field scale (Fig. 5). A result showed that this relation could be established despite the causality between the nitrates losses and use of the land is not direct (Jansons *et al*., 2002; Lagzdins, 2013).

Point source agricultural pollution

The impact studies by Haraldsen *et al*. (1998), Jansons (1998), Sudars *et al*. (2005), and Berzina *et al*. (2009) give examples of a long-term investigation into the consequences of point source pollution on the water quality. Measurement results presented by Jansons *et al*. (2002) in catchments with current or past high animal densities (including pig farms with production capacities of 10–30 thousand pigs per year) showed very high losses, with an average of 46–48 kg N ha^{-1} and 2.7–3.4 kg P ha^{-1} per year. Data on phosphorus loads in the Bauska and Ogre catchments reflect an extreme deviation from natural water quality status, and point sources are assumed to have major impact via direct run-off of applied slurry. Moreover, in one particular slurry dumping field of 50 ha in the Bauska catchment, losses exceeding 10 kg P and 250 kg N ha^{-1} annually were recorded. In one of these catchments (Ogre), farming activities ceased in 1991/92. Results indicate (Fig. 6) that such farmland still may function as "area point-sources" with risk of significant losses of nutrients to the aquatic environment (Jansons *et al*., 2002).

Risk assessment of agricultural pollution

A Geographic Information System, which is designed to organize, store, and access large quantities of spatially referenced data, is an excellent tool for the assessment of environmental risk of agriculture. Due to the lack of monitoring data, the first designation of vulnerable zones in Latvia was performed using GIS Multi-Criteria decision-making analysis (Kirsteina, Dzalbe, 2000). There are two main groups of the factors: natural impact, and the impact of human activities. The nitrate pollution risk assessment was based on the data on soil and groundwater media, run-off, potential erosion risk, agricultural activities, such as agricultural land and arable land use, animal density, soil drainage, and application of fertilizers (Jansons *et al*., 2005). These factors have been used for the GIS Multi-Criteria decision-making analysis. Statistical data traditionally available at administrative level was merged with georeferenced land cover data, and maps are presented pointing out the impact of different factors. Factor weights have been computed according to the results of the expert evaluation. The resulting impact data layer yields a map for potential agricultural risk areas in Latvia. The result of this scientific approach was used for designation of vulnerable zones in respect of the EU and national legislation (the Nitrate Directive). Finally, part of the territory in the central part of the country, in the Lielupe river basin, or Dobele, Jelgava, Bauska and Riga administrative regions, with the most intensive agricultural production and highest pollution risk, were designated as nitrate vulnerable zone (NVZ). The designation of NVZs should be revised every four years, unless not the whole territory of the country is designated as NVZ. The procedure demonstrated in this study seems to provide an effective method to assessing the environmental impact from the regional perspective. It may also be used to provide a first assessment at the regional level before zooming in to focus on specific conditions, such as nitrates and eutrophication, for detailed analyses.

The proper farming profile, methods, and several restrictions for the territory of NVZs should be used according to the crop, weather and soil conditions (Jansons, 1999). Therefore, the first

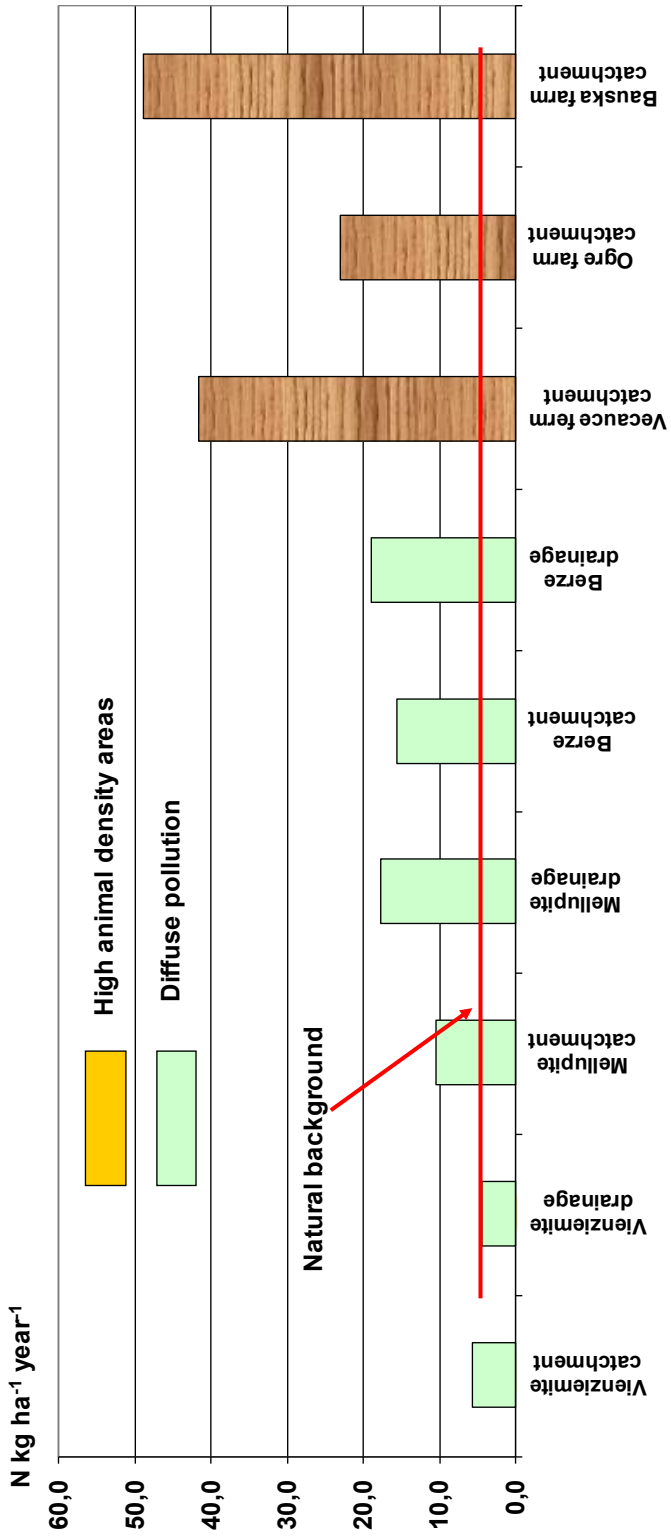

Fig. 6. Mean values of nitrogen losses from agricultural non-point sources and point sources (high animal density areas, 1994–1999).

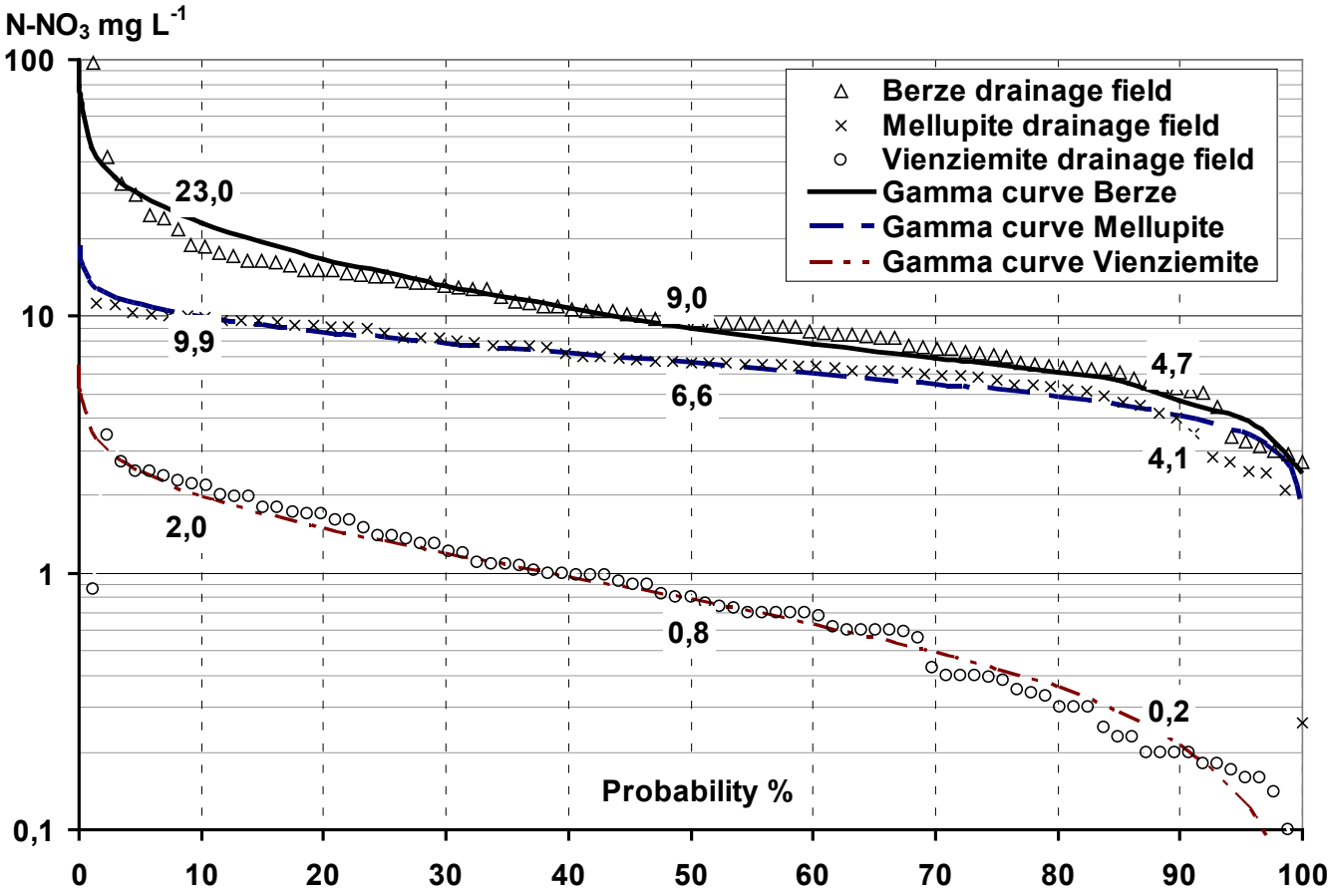

Fig. 7. Probability curves for the NO_3–N winter concentration in the drainage field run-off.

version of the Code of Good Agricultural Practice (Busmanis *et al*., 1999) was prepared by the LLU scientists in a joint Danish-Latvian Project coordinated by P. Busmanis.

Pollution risk is an unavoidable element of our everyday activities, and is also unavoidable in agricultural sector (Dzalbe *et al*., 2005; Jansons *et al*., 2007; Berzina *et al*., 2008). There is always a degree of uncertainty about the type, e.g. soil loss, nitrogen and phosphorus concentrations (Berzina *et al*., 2007), and extent of adverse impacts which could arise. Probability analysis that is a common method in hydrologic studies could be used to describe the water quality, e.g. the likelihood of an event where an event is defined as occurrence of a specified value of the random variable (Jansons *et al*., 2009). The assessment of the long-term data series (1994–2007), obtained from the non-point source agricultural run-off monitoring programme, has shown that nitrate nitrogen concentrations depend on the scale of monitoring system (drainage plot, drainage field, small catchment) and intensity of agricultural production system. The available long-term data series and use of the probability curves allow the assessment of the variations of nitrate concentration on the scale of the plots, drainage fields and small catchments. Jansons *et al*. (2009) presented the estimation of risk exceeding the threshold limits (11.3 mg L^{-1} NO_3-N) of the nitrates concentrations. High risk to reach nitrates concentrations over the limits has been found (about 30% of samples) in field drainage of the Bērze monitoring site (Fig. 7). With regard to the small catchments' scale, nitrates concentrations over limits could be expected (15% of samples) in the Bērze catchment with high intensity of agriculture.

Table 2

Recommendations for water quality (N_{tot} and P_{tot}) standards in agricultural areas

Quality	N_{tot}, mg L^{-1}		P_{tot}, mg L^{-1}	
	field drainage runoff	channel and main drain run-off	field drainage runoff	channel and main drain run-off
High	<4.5	<1.5	<0.015	<0.025
Good	4.5-5.5	1.5-2.5	0.015-0.020	0.025-0.050
Moderate	5.5-10.0	2.5-7.5	0.020-0.075	0.050-0.150
Poor	10.0-12.0	7.5-10.5	0.075-0.135	0.150-0.250
Bad	>12.0	>10.5	>0.135	>0.250

Highest risk to reach nitrates concentrations over the limits was reported by Sudars *et al*. (2005) in Bauska pig farm point-source monitoring point. About 77% of water samples in a drainage channel from a 50-ha slurry utilization field had the nitrates concentrations over limits during the period of 1995–2003.

To some degree the presented study and interpretation of nitrate data may be used for designation of water quality standards and for designation of nitrate vulnerable zones.

Water quality standards for the agricultural run-off

For EU Member States, the overall aim of the Water Framework Directive (WFD) is to achieve "good ecological status" and "good surface water chemical status" in all water bodies by 2015. Lagzdins *et al*. (2007a, 2007b, 2008) summarized data of water quality that was collected monthly over 13 years (1994–2006) in Latvia agricultural monitoring sites. All available total nitrogen (N_{tot}) and total phosphorus (P_{tot}) concentration data were analyzed using normal distribution curves. Percentile selections of data plotted as frequency distribution were used to establish boundaries of water quality standards. The research showed that in small agricultural streams good chemical status represents concentrations of <2.5 mg N_{tot} L^{-1} and <0.05 mg P_{tot} L^{-1}, but in drainage system water – <5.5 mg N_{tot} L^{-1} and < 0.02 mg P_{tot} L^{-1}. This paper (Lagzdins *et al*., 2008) also deals with surface water quality assessment and recommendations for the classification system based on nutrients concentrations (Table 2).

From monitoring to the discharge and water quality modeling

Due to the costs and practical aspects, it is not possible to measure the complete load of nutrients from agriculture. The spatial and temporal variability in loads can be very large, due to natural conditions and differences in agricultural practices. Thus, the practical approach is to monitor in pilot areas supposed to represent typical conditions with regard to climate, soils, crops, and management practices. However, from the viewpoint of the marine environment and the regional drainage basin level management, it is a prerequisite to know the total loads from agricultural activities. Specific tools (models) are therefore used to up-scale the monitoring results from pilot areas (drainage fields, small catchments) to the river basin (regional) level, and for this reason modeling and monitoring are integrated parts in future management schemes of non-point sources in agriculture.

An important part of water quality modeling is hydrological models. In many cases, these models are integrated into a water quality models. Development of hydrological models by A. Ziverts started in LLU in the 1990s. Since 1995, the professor has participated in one of the world's largest projects within hydrometeorology – BALTEX. Several versions of conceptual mathematical model METQ for modeling of hydrological processes (METQ96, METQ98, METQ2007BDOPT) were calibrated and tested during 1996–2007. Description of the hydrological processes of METQ is similar to the HBV-type watershed simulation model developed in SMHI (Sweden). The METQ model allows simulating the daily runoff regime as well as actual evapotranspiration, water storage in different soil layers, groundwater table dynamics, and other elements of water balance (Ziverts, Jauja, 1999). METQ98 has 22 input parameters; some of the parameters should be calibrated. The METQ was tested for the application in the river basins with various sizes, including large-scale river basins like Daugava river (Jauja, 1999) where maximal flood discharge was modelled (e.g. as regards Riga HPS, flood discharge might be 15 100 ... 16 500 $m^3 s^{-1}$).

Moreover, METQ was used for discharge modelling of medium size rivers (Apsite *et al*., 2008) and agricultural monitoring points in small catchments and drainage fields where measurement structures are not constructed.

Complex watershed models can be extremely powerful tools to assist in the development, implementation, and development of practical water quality management strategies in agriculture. Water quality simulation and modeling for that purpose so far was not developed in Latvia. Therefore, for simulation of the water quality, the FyrisNP model, developed in Swedish University of Agricultural Sciences (SLU), was selected. The cooperation between the Department and SLU was continued in the Baltic Sea Regional Project (BSRP) (2004–2007). Furthermore, a comprehensive training and upgrading of the modeling competence is considered a significant contribution to the capacity building in management of agricultural pollution. Therefore, experience and BSRP created additional research capacities of the research team of the Department that had very positive future development in the field of modelling implemented in National Research Project (NRP): "Climate Change Impact on Water Environment in Latvia (2006–2009)". The Department is responsible for work package – WP2 Climate Ghange Impact to the Nutrient Run-off from Drainage Basin[1]. Implementation of the research results will develop capacities for water quality modeling, where progress in Latvia has been too slow. FyrisNP model was validated for water quality assessment in the Berze river (Abramenko, 2013). This modeling activity has establish an empirical link between water quality and load measurements on the field and small catchment scale (Berze monitoring station), and at medium-sized river level (Berze River). The assessment of the Fyris model performance and the applicability of the models supported implementation of the required activities of WFD and could be used for evaluation of Latvia share of nutrient load in pollution of the Baltic Sea. Water quality sampling programme, which started in the year 2005, provided data for first attempts of simulation for the Berze river and its 15 sub-catchments. The results of modeling for sub-catchment 12 are shown in Fig. 7. The results of Fyris model calibration showed a good coincidence (r=0.71) between simulated and measured nitrogen concentrations for the calibration period 2000–2012. It is necessary to take into account that water quality samples were collected on event basis by Latvia Agency of Hydrometeorology (2000–2004), but since 2005 on monthly basis by the Department of Environmental Engineering and Water Management.

[1] See: http://kalme.daba.lv/en/wp2/

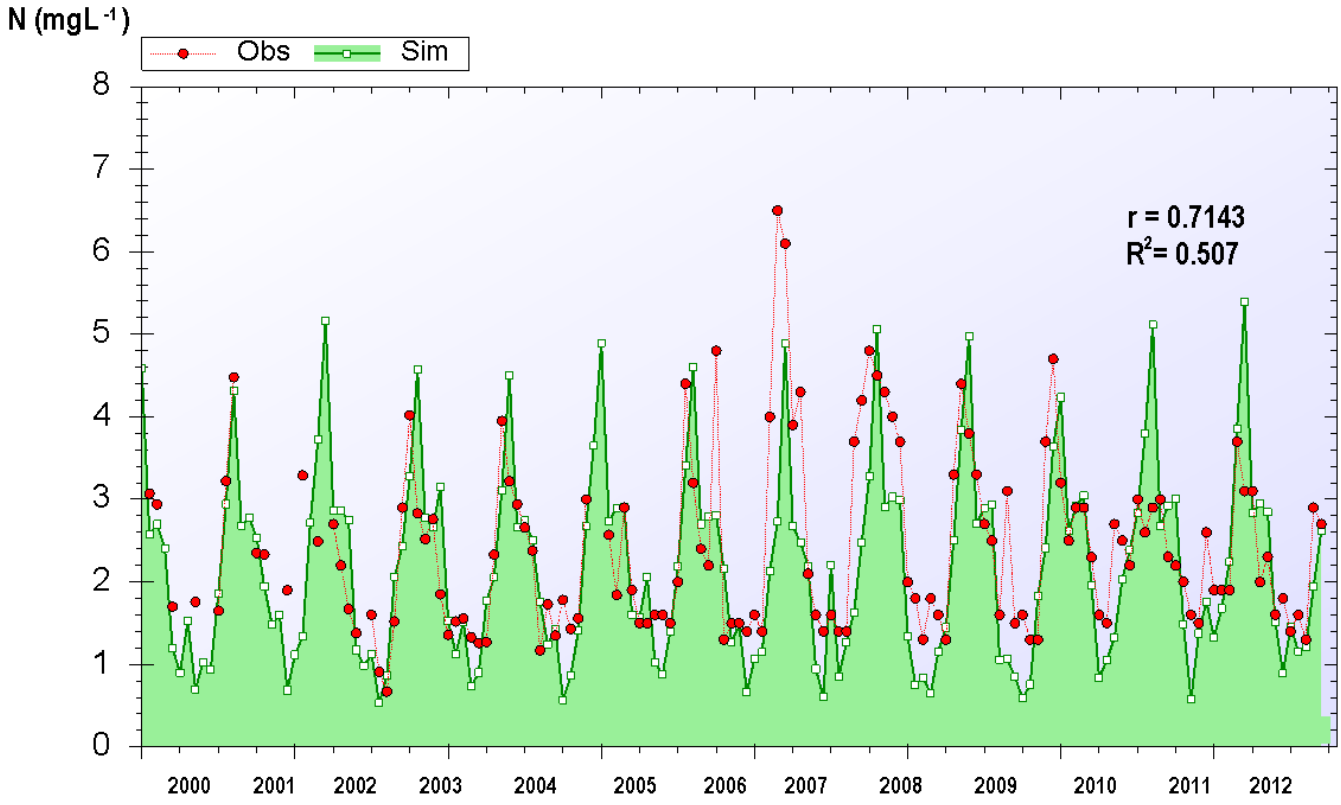

Fig. 7. Measured and simulated nitrogen concentrations in Berze river.

Taking into account the variation of weather conditions, successful modeling approaches in future will depend on the availability of long-term data series of water quality for river and sub-catchments. Experience from other sites suggests that longer data series and data runs than those gathered in the Berze river basin would be required to improve the results of modeling. In 2006, groundwater studies started in Berze, Mellupite and Auce monitoring sites to assess the agricultural impact on shallow groundwaters. For this purpose, additional observation wells were installed for groundwater sampling (Vircavs *et al*., 2011). For modelling of groundwater regime under the different meteorological conditions, hourly groundwater levels collected by data loggers were used.

Summary and conclusions

Agricultural and environmental problems should be analyzed on a different scale, taking into account the natural and anthropogenic impacts. The examples discussed here illustrate how the theory, research and practice of agro-environmental studies, in contact with other disciplines such as ecology, hydrogeology, soil science, GIS, and mathematical modeling, address the most urgent water management problems faced by society in Latvia.

Environmental conditions, such as weather, water balance parameters, soil type and fertility, soil moisture, and the stochastic variability of these conditions, in turn, influence nutrient losses in the non-point sources. The issue of interactions between natural variability (soil, hydrology) and human impacts on different scales is very complex and requires further investigations.

An important finding of the research is that water quality standards for drainage water as well as for small catchments with intensive agriculture should be less stringent than for rivers, otherwise it will not be possible to fulfil the objectives set by the WFD in agricultural areas.

A further recommendation is that modeling should be a key component of catchment management systems. This technique allows the assessment of management actions that are difficult to quantify through environmental monitoring, linking the catchment-scale evaluation of pollution sources with the effects of management changes implemented on farm scale.

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Research in Geodesy and Land Management at the Latvia University of Agriculture

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Abstract. The paper gives an overview of the directions and results of research carried out in geodesy and land management at the Latvia University of Agriculture from the year 1939, when the Surveying Department (later the Department of Geodesy) was established, up to the present day. Since the beginnings of the Department, researches in geodesy have been associated with problems of precise leveling: vertical movements of the earth crust, deformation of buildings and structures, as well as accuracy evaluation of geodetic instruments. Researches in land management started with the establishment of the Department of Land Management in 1951, and traditionally they are associated with rational land use issues. After the merger of both the Departments in 2001 and Latvia's integration into the European Union, the research topics have expanded: Now they include assessment of the accuracy of the leveling core network and the measurements associated with it, as well as evaluation of the aspects of land property formation and improvement.
Key words: Geodesy, land management, research, leveling, land use.

Introduction

Researches carried out in geodesy and land management at the Latvia University of Agriculture (LLU) are related to the educational and scientific work of the teaching staff at the Department of Land Management and Geodesy. The Surveying Department was established as a part of the Faculty of Forestry of the Jelgava Academy of Agriculture (later – the Latvian Agricultural Academy [LAA]) in August 1939. In 1947, when the Faculty of Land Management was established, the Surveying Department was renamed the Department of Geodesy and was incorporated as part of the new Faculty. In 1951, the Department of Land Management was established. Then, 50 years later, in 2001, both the Departments were merged and the Department of Land Management and Geodesy was established.

The main research object – the land – for geodesists and land use planners is the same, but the scope of research and education in geodesy and in land use planning differs: Research in geodesy deals with technical issues, but in land use planning – with economic and legal issues. For this reason, researches in geodesy and in land use planning are discussed separately further in the paper.

Research at the Department of Geodesy (1939–2001)

For many years, scientific work at the Department of Geodesy has been devoted mostly to the problems of precise leveling. This was largely influenced by the scientific interests of prof. J. Biķis, who was nominated as the first head of the Department.

The main scientific research directions in that period were:

- vertical movements of the Earth's crust and stability of benchmarks:
  - on the Baltic Sea coast (J. Biķis, O. Jakubovskis),
  - in the Pļaviņas geodynamic landfill (L. Ozols, Ē. Indriksons, R. Krūpens),
  - in the Riga city (G. Aberbergs);

- geometric leveling method, instruments, precision, effect of external conditions in leveling (J. Biķis, V. Freijs, R. Krūpens, M. Kronbergs, E. Indriksons);
- hydrographic leveling (J. Biķis, O. Jakubovskis);
- mathematical processing of geodetic measurements, alignment of observations, and assessment of the accuracy of results (V. Freijs);
- state triangulation (L. Ozols);
- geodetic astronomy (F. Gončarovs);
- engineering geodesy, and studies of the deformation of buildings and constructions (O. Jakubovskis, M. Kronbergs, U. Zuments, B. Helfriča).

One Doctoral dissertation (V. Freijs in 1971) and five dissertations of the candidate of science (V. Freijs in 1951, G. Aberbergs in 1954, S. Kurojedovs in 1955, O. Jakubovskis in 1967, R. Krūpens in 1971, and U. Zuments in 1982) have been developed and defended.

The main results of the research

The results of researches carried out by prof. J. Biķis and assistant professors V. Freijs and L. Ozols contributed to the increase in leveling accuracy as well as to the examination of error sources. Those precise leveling issues were most topical not only for the development of the overall USSR geodetic height network, but also for the studies of contemporary vertical movements of the Earth's crust (Ozols, 1961; Озол, Крупен, 1965).

Already at the end of the 1940s, senior lecturer of the Department of Geodesy G. Aberbergs, on the initiative of prof. J. Biķis, studied vertical movements of the earth's surface in the Riga city. In 1954, he published the first data about elevation changes of the Riga leveling network points, which revealed not only the general nature of the area sinking but also identified a number of separate areas where the sinking reached around 8 mm per year, for example, in the Sarkandaugava lowlands. Subsequent installation and repetitive leveling works of the Riga city geodetic height network points were based on G. Aberbergs' researches (Aberbergs, 1959). His research themes were associated also with the general problem of the construction science "building–foundation–base", which was topical in the design and construction of buildings.

Determination of deformations in the foundations of buildings and civil engineering constructions was based primarily on the method of periodically repeated precise leveling of geodetic height and deformation marks. Engineering design specialists as well as teaching staff of higher education institutions, including the LLU Department of Geodesy, were involved in researches on deformations of constructions, industrial buildings, bridges, and other structures (Helfriča, Ieviņš, Kronbergs, 1992).

In 1960, assistant prof. L. Ozols joined the Earth's crust movement research committee established in the Baltic Republics, and on behalf of this Committee he organized a special precise leveling site to systematically investigate the effect of the Pļaviņas HES water reservoir's mass on the geological layers in the vicinity of the flooded areas (Ozols, 1961). Previously performed geological studies indicated likelihood of unpredictable tectonic movements in this area. In order to clarify this phenomenon, a ground benchmarks network, about 180 km in length, was installed around the Pļaviņas HES water reservoir. The network was observed before and after filling the water reservoir by means of the precise leveling method. The teaching staff (Ē. Indriksons, M. Kronbergs, R. Krūpens, and I. Plecis) and senior students of the Department of Geodesy participated in the leveling works. The analysis of periodically repeated observations showed that

in the area of the water reservoir, relatively small ground surface movements were detectable – in different places they did not exceed 1–2 mm per year (Озол, Крупен, 1965; Индриксон, 1976; Indriksons, 1995).

In the studies of the Earth's crust vertical movements, O. Jakubovskis' research of hydrographic leveling methods for the increase of accuracy achieved further scientific advancement (Якубовский, 1989). O. Jakubovskis calculated characteristics of vertical movements for the Baltic Sea coast area; afterwards they were widely used by researchers of different other countries.

In geodetic network adjustment theory, at the end of the 1950s, a research program on lower class triangulation issues was developed under the leadership of assistant prof. V. Freijs. As a result, computation tables were obtained, which simplified processing of geodetic measurements without detracting from equation rigidity by the principle of the least squares method (Фрейс, 1956). V. Freijs conducted researches on geodetic height network densification and analyzed accuracy of the existing network according to the equalization results. His studies not only integrated well into the joint research direction of the Department and promoted the analysis of height changes in the Pļaviņas HES geodynamic site, but also contributed to the scientific development of the Department's graduate students.

Studies of the methods of the triangulation and leveling network progressive adjustment with equivalent replacement techniques provided an opportunity to improve the classical theory and to eliminate the practical difficulties arising due to supplementation of the previous measurements with new, higher precision measurements for their simultaneous equalization. On these issues, V. Freijs published a series of studies in the LAA scientific articles in the 1960s. This broad research topic was finally developed in his Doctoral dissertation (Фрейс, 1971).

Besides precise leveling, the research interests of the teaching staff of the Department of Geodesy have always encompassed determination of the precision of geodetic instruments and of the external conditions in leveling; these themes were also discussed in R. Krūpens' dissertation of the Candidate of Sciences (Krūpens, 1959).

From the year 1973 to 1976, by the order of the Soviet Union's gas holding scientific research institute, deformations of a frozen ground shell of an experimental underground reservoir were studied in the Riga liquefied gas base. Four-year measurements demonstrated a generally steady rise of the entire reservoir by an average of 1.7 mm per year; however, no significant deformities of the reservoir's walls were observed (O. Jakubovskis, M. Kronbergs, J. Smilga).

Later, from 1977 to 1990, deformations of the foundations of the TEC-1 production block and bridge constructions were examined. During the observation period, greater sinking (up to 10 mm) of the foundations was observed for the machine hall and the smoke pumping hall, but for one of the turbines – even up to 20 mm. It was found that settling of three chimneys did not exceed 5 mm (M. Kronbergs, U. Zuments, A. Mazkalniņš).

In 1997, measurements of vertical deformations of Salaspils nuclear reactor were undertaken because of the prospective opening of the gypsum quarries near the reactor.

Research activities of the teaching staff of the Department of Land Management during 1951–2001

In order to accomplish scientific researches, an extensive territory survey was carried out in previously selected standard farms of various Latvia's regions. Close ties were established and

maintained with central and regional land use planning services, farm managers, professionals and land use planning performers (Zemes ierīcības ..., 2007).

Teaching staff of the Department of Land Management elaborated experimental land use projects for the standard farms as well as assisted in their implementation. The changes that occurred and their impact on economic activity results were studied. The studies covered the LAA Training and Research Farms "Jelgava" and "Vecauce", and farms of Aizkraukle, Alūksne, Daugavpils, Gulbene, Saldus, Valmiera, and other regions.

Till 1961, research activities of the Department of Land Management mainly included issues of restructuring and optimization of the structure and areas of agricultural lands established during collectivization, as well as analysis of the results of ongoing process. These research themes were set and funded by the governing institutions of Latvia and the Soviet Union (Zemes ierīcības ..., 2007).

The most important research topics of that period were:

- land use in large farms and establishment of their borders, as well as elimination of deficiencies;
- development and approbation of the methodology for calculations of in-farm transportation costs and for reduction of production costs;
- land recording measures and improvement of the exploitation of obtained results;
- activities of the development of the farm's internal land use projects and their implementation, which included:
  - expansion of land use types, and designing of crop rotation fields;
  - determination of the usefulness and of the future use of neglected agricultural lands;
  - distribution of cultivated pastures, and designing of their territories.

In 1961, the Research Laboratory of the District's planning and spatial organization was established and attached to the Department of Land Management, which gave a possibility of covering a wider range of research problems as well as of linking the researches closer to the speciality's production organizations. In the first half of the 1970s, in collaboration with assistant prof. Arvīds Brūvers of the Department of Economic Cybernetics, researchers of the Department of Land Management began using computational technique, which was widely applied in the studies of land use improvement in large farms (Лоцмер, Брувер, 1974; Лоцмер, 1977).

From 1962 to 1975, the Department's teaching staff together with the staff of the Research Laboratory was involved in the large, complex, multi-department joint research theme "Science-based system's development for advancement of agriculture and livestock in the naturally economic zones of Latvian SSR". The staff of the Department and Laboratory studied one of the most important problems of the joint theme "Rational organization and establishment of the Land Fund in the Latvian SSR". The studies included:

- types of land use, monitoring of their use conditions and analysis of land areas contours;
- analysis of the placement of sown areas as well as of the possibilities for their enlargement (Менготс, 1973);
- development of the farm's internal land use planning projects and their implementation by using land evaluation materials more extensively (Гатер, 1964);
- rational arrangement of the farm's internal road network (Ставаусис, 1973);
- organization and design of irrigated cultivated pasture territories;
- coordination of the elaboration of land use planning and land reclamation projects;
- analysis of the compactness and stability of farm territories, as well as development of methodologies for prevention of the identified deficiencies (Амола, 1977; Бутане, 1977);

- development of methodologies for performance of regular land inventory work by implementing land inventory maps (Канавиньш, 1967);
- determination of the location and rational sizes of villages and industrial centers by drawing up the district planning schemes.

After the year 1976, the complex research theme was continued and more attention was paid to organization of the farm's territory, to land use, and to protection of land resources, related to further specialization and intensification of agricultural production.

Until the restoration of Latvia's independence, main research interests included:

- development of theoretical aspects of inter-farm land use planning;
- development of methodology for greened area planning schemes;
- methodology and justification of the location of the farms' regional centers by establishing agricultural agro-industrial complexes;
- improvement of the elaboration of the farms' internal land use projects, and supervision over their implementation;
- land use of populated places;
- dynamics of the types of land use during 1946–90, and analysis of the coherence of changes.

After regaining Latvia's independence, the Department's teaching staff, under the guidance of prof. M. Locmers, together with the experts of the institute "Zemesprojekts" and the State Land Service actively participated in the elaboration of laws and regulations pertaining to the Land reform and land cadastre, in the implementation of Phase I measures (1990–96) of the Land reform, particularly in the establishment of private farms, and, after the year 1996, in the elaboration of Phase II measures of the Land reform, related to farm privatization and arrangement of property rights (Zemes ierīcības ..., 2007). Simultaneously were evaluated the results of the Land reform (Locmers, Palabinska, 1997).

Since 1991/92, the Department's teaching staff together with prof. A. Boruks, director of the institute "Zemesprojekts" M. Eglītis and cadastre expert V. Paršova have been researching issues of the restoration, establishment and maintenance of the Cadastral system.

In 1994–96, under the guidance of prof. M. Locmers, teaching staff of the Department carried out the research theme "Scientific justification of the development of the Land reform, and confirmation of its results". While carrying out this theme:

- the concept of basic cadastral regulations was developed by setting the objective, tasks, principles, content and other conditions for the creation of real estate cadastre;
- methodological and methodical rules for drawing up the land use planning projects were developed by implementing the Land reform in cities;
- together with scientists of research institutes and the Latvia University of Agriculture (LLU) and with specialists of the Ministry of Agriculture and of the State Land Service, the land areas needed for research institutes, for breeding and research stations, and for study farms were determined;
- basic instructions of land use arrangement were developed for research institutes, for breeding and research stations, and for study farms;
- recommendations were elaborated for admissibility of the farm land use (land property) division.

In cooperation with other LLU departments, the Society of Surveyors of Germany, the Latvian Land Cadastre Centre, and the head of Gaujiena rural municipality of Aluksne district M. Kalniņa, the teaching staff of the Department (A. Jankava, A. Palabinska, and H. Kanaviņš)

developed the concept for spatial planning of Gaujiena rural municipality. Broad sociological studies of the private farms (provision with equipment, buildings, livestock and land) of this rural municipality during the first years of the Land reform were carried out, involving also the students of the Land use planning speciality (Jankava, Kanaviņš, Palabinska, 1997).

From 1997 to 1998, research was done on the area, composition and distribution of land not divided during the Land reform in Latvia in general, as well as on suitability and prospects for use of the undivided lands in rural municipalities of the Daugavpils and Gulbene districts (Butāne, Kanaviņš, 1997).

From 1998, farmland consolidation preconditions and their application methodology have been studied under the guidance of M. Locmers, and later – under the guidance of A. Jankava (Лоцмер, Янкава, 2001).

Teaching staff of the Department have developed and defended two Doctoral dissertations (V. Timofejevs in 1971, and M. Locmers in 1981) and seven dissertations of the candidate of science (M. Locmers in 1963, H. Kanaviņš in 1967, S. Kokins in 1976, V. Paršova in 1979, A. Amola [Jankava] in 1981, A. Butāne in 1984, and M. Mengots in 1987).

Scientific research at the Department of Land Management and Geodesy since 2001

After the merger of both the Departments, teaching staff of the Department of Land Management and Geodesy continued researches in the ongoing directions.

In 2000, class I, II and III leveling instructions were developed under the guidance of lecturer M. Kronbergs, and, in a six-year period (starting from 2001), the team of the Department's teaching staff and employees accomplished class I leveling by 7 leveling lines, which resulted in acquisition of a significant amount of valuable data for researches of leveling error sources.

After completion of class I leveling of Latvia, the results obtained in separate Latvia's regions as well as in the whole country were analyzed. Leveling kilometric standard deviation, according to Latvian Geospatial Information Agency preliminary data, was 0.78 mm, which, regardless of today's modern levelers, is higher than in the precise prewar leveling (Celms, Kronbergs, Cintiņa, 2012). The causes of decrease in leveling preciseness will be investigated.

Under the leadership of M. Kronbergs, measurements of the vertical deformation of Salaspils nuclear reactor's buildings are being continued. The measurements performed within 15 years indicate an uneven compaction of structures – from 5 to 62 mm depending on the type of the building and its location in the area of the reactor. The compaction may be due to a significant lowering of the groundwater level during the rock gypsum quarry establishment.

To establish the accuracy of global positioning elevation determination, global positioning measurements of separate class I leveling network points are initiated in the whole territory of Latvia. In 2012, investigations were started to clarify the cause of the inexact coordinates of local geodetic network points (A. Celms, A. Brants).

Different methods for height transfer across wide water bodies have been studied, on which a patent has been obtained – patent No. 14529 "Device and method for precise leveling stripe rod reading for long distances" (Celms, Kronbergs, 2011). It has been planned to study the applicability of laser scanning in observations of building deformations as well as to start measurements of the Jelgava Palace deformations.

In the last few years, studies in the field of land management have been connected with the new features of the real estate registration, accounting and management (Paršova, Boruks, 2009),

with the real estate evaluation aspects (Baumane, 2011), as well as with evaluation of the Land reform results (Янкава, 2010) and with spatial planning aspects (Палабинска, Паршова, 2012). For several years, researches carried out at the Department have been related to farm tenure and identification of the property's territorial situation as well as to feasibility of land consolidation (Platonova, Jankava, 2011). In some pre-selected rural municipalities, under the leadership of prof. V. Paršova, territory surveying was carried out and surveys of landowners were conducted to clarify the situation in Latvian countryside after the Land reform implementation, as well as to search for solutions for further optimization of land use; these activities are expected to be continued.

As a scientific contribution to the Department should also be noted I. Bīmane's researches on professional competence in geodesy studies; in 2012, she earned her Doctor's degree in Pedagogy (Bīmane, 2012). As the result of researches carried out at the Department, Doctoral degree in Economics was awarded to V. Baumane (2011) and V. Vesperis (2012).

Although scientific researches in geodesy significantly differ from those in land use planning and cadastre, it does not create an obstacle but even favours to popularization of scientific researches and promotes cooperation with other universities in Latvia and abroad.

Since 2002, the Department of Land Management and Geodesy has organized four international scientific conferences "Baltic Surveying", where participated the teaching staff, researchers and practitioners of land management and surveying industry from Latvia, Lithuania, Estonia, Germany, Russia, Moldova, Romania, and Poland. The scientific proceedings of these conferences were prepared jointly with foreign partners.

Since 2006, at the end of each year, in order to bring the university closer to practice and to jointly solve the problems related to speciality, the Department organizes scientific and practical conference "Land management and surveying problems", which has made a great response from both practitioners and representatives of the Latvian universities.

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Research at the Faculty of Food Technology

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Abstract. Human life is based on nutrients. Their balance and share in food products influence not only the health and development of an individual, but also the whole society. Therefore it is essential that food products possess certain features suitable for an individual which could be defined as food product quality. The main research areas in food science and technology deal with food in all its aspects starting with raw materials, analysis and development of processes and technologies, and ending with safety, healthiness and quality of ready-to-eat food products. The aim of this review is to show the development of the research activities in food science and technology at the Faculty of Food Technology. Technologies have always played an important role in the development of science; the main research field of their development is preservation and optimization of the most important substances present in food. Minimum processing principles could be applicable, for example, introducing non-thermal processing technologies. The new technologies should meet market requirements; they should be profitable, competitive, and relevant to international development tendencies in this direction, open to further development and improvement. Four basic conditions are necessary for the implementation of a new technological process: clear strategy, business process, resources, and organization.
Key words: Research field, food, technology, quality, scientific work, equipment.

Introduction

Since the foundation of the Faculty of Food Technology in 1948, the word *science* has been associated with two legendary personalities – professors Pāvils Zariņš and Jānis Āboliņš. However, in those times, research work was mainly connected with practice – development of new equipment, and its implementation on farms or in food enterprises. The basic objective of the Faculty was to prepare competent engineers of food industry. Volunteer students were welcome to participate in scientific research groups, but who of them wanted to volunteer? Without scientific research there is no progress in any of the branches, so there were enthusiasts interested in science, experiments and investigations. They themselves had to develop experimental equipment and to search for information in books.

New trends appeared in the Food Technology Department in 1971, when a Research Laboratory was established to implement environmentally friendly technology of non-residue milk processing, supervised by prof. P. Zariņš. In those days, that was the most modern laboratory developed at the Academy of Agriculture (former name of the Latvia University of Agriculture), and in 1980 it was awarded the prize of the Latvian Soviet Socialist Republic in science and production.

In Latvia, during the years of its national revival, the existing infrastructure was destroyed, and the Research Laboratory as well. There was a lack of funding; in addition, most of the equipment, which once used to be modern, had become outdated, therefore everything had to be started from zero.

At present, it is impossible to conduct any research and experiments without the students' participation, as the scientific research is a significant part of the study process. Now, the most interesting stage has started in the history of the Faculty.

The basic task of the Faculty of Food Technology is education of proficient food technologists and scientists for food industry, catering, hotel management, and research. During the last decade, the teaching staff, researchers, as well as postgraduate, master and bachelor students of the Faculty of Food Technology have been working intensively in the scientific field. The post-war years, when significant changes took place, as well as the later period, when there was a seemingly endless fight for the existence of the Faculty, were only the beginning of maturity, the beginning of active scientific investigations, development, and achievements.

An important international cooperation has been developed as well. Many of the Faculty's staff and postgraduates have had a possibility to be involved in different international projects and workshops and to participate in conferences, study courses, and short-term on-site training programs. Many young researchers have defended their thesis, which has been supported by the European Social Fund grants allowing attendance at international conferences and workshops. It should be mentioned that there was a unique situation, which has never happened before and is not likely to happen again, when four young staff members from one and the same department, at one and the same time, were working on their doctor's thesis. The close cooperation between PhD students and their supervisors facilitates success of the young researchers. The experience and advice of the supervisors have helped the young researchers to prepare high-quality doctoral thesis in due time. The continuous development of research activities is the basis for new research facilities, for improvement of education quality, and for long-term cooperation with international partners.

The development of the research activities in food science and technology at the Faculty of Food Technology are related to the following issues:

- arrangement of research facilities at the Faculty of Food Technology;
- development of new food products from the raw materials of plant and animal origin and their production technologies;
- researches to ensure food quality and safety;
- study of the influence of the new-generation packaging materials on food quality and shelf-life extension;

Summing up the contribution of each department of the Faculty and its staff members in the development of food science during the 65 years of its history, we have to deal with every department involved in the common work, as specific fields of the research activities are concentrated in every department.

Department of Food Product Technology

In 1948, the Department of Food Product Technology was established on the basis of the former Department of Agriculture Technology at the University of Latvia (afterwards the Jelgava Agricultural Academy). Up to 1946, the Department of Agriculture Technology was headed by prof. Pēteris Delle. In 1948, rector Pēteris Peive decided to include the Department of Agriculture Technology in the Faculty of Food Processing Technology, and to rename it the Department of Food Product Technology. The newly established Department was headed by assistant prof. Pāvils Zariņš (1948–1962).

It is worth mentioning that the prominent milk and milk product technology specialist professor Mihails Kazanskis worked at the Latvia Academy of Agriculture from 1952 to 1956. At that time, the professor was the only Doctor of engineering sciences in the speciality of milk and milk product technologies in the Soviet Union. The presence of M. Kazanskis at the Faculty was an important contribution both in the improvement of the study process quality and in the development of scientific theories; besides, it was one of the reasons of splitting the Department of Food Product Technology into two departments in 1952. One of the departments retained its previous name, but the other was named the Department of Milk Product Technology and was headed by prof. M. Kazanskis. In 1956, prof. Kazanskis moved to Leningrad and the departments were again united under the previous name – the Department of Food Product Technology. The head of the Department became assistant prof. P. Zariņš. Shortly afterwards he was appointed as the rector of the Latvia Academy of Agriculture, and in the time period from 1962 to 1966, the Department was headed by assistant prof. Oskars Plaude; from 1966 to 1968 – by assistant prof. Aleksejs Daņiļevičs; and in 1968, prof. P. Zariņš repeatedly became the head of the Department. In 1984, assistant prof. Envija Velga Strautniece was nominated to head the Department.

The qualification of the academic staff of the Department has always been very high. Initially, from 1948 to 1960, 37% of the academic staff held the scientific degrees (Candidate of engineering sciences, or Doctor of engineering sciences). Later, from 1960 to 1975, when the new generation of scientists (A. Daņiļevičs, I. Melgalve, L. Ozola, E.V. Strautniece) started to work at the Department, 64% of them held scientific degrees. Later, in 1975–1990, 61% of the teaching staff had scientific degrees.

In 1993, the LLU Habilitation and Promotion Scientific Council was established in the branch of engineering sciences, sub-branch of food technologies, processes and machinery. Originally, the Council dealt with comparing the scientific degrees of the former Soviet Union to the degrees of Doctors and Doctors Habilitatus adopted in the Republic of Latvia (nostrification). After evaluating the content of the doctoral thesis and the applicants' scientific activities, four of them were nostrified (assistant professors L. Ozola, L. Skudra, V. Rubene, and E.V. Strautniece). In 1993, L. Markeviča joined the group of Doctors in engineering sciences.

The researchers continued their work on scientific themes started by prof. P. Delle at the Department of Food Product Technology, namely, analysed the chemical content of fruit and berries, their suitability for preparing juice, wine and preservatives (assist. professors J. Riekstiņš, F. Angers, and O. Plaude). Assistant prof. J. Riekstiņš introduced a brand new wine yeast variety that was widely used in wineries of Latvia; A. Daņiļevičs researched intensification processes of grain thermal processing; I. Āboliņa analyzed the chemical composition of chokeberries as well as their processed products; I. Melgalve analyzed the chemical composition of fruits and berries, their suitability for processing and production; E.V. Strautniece studied chemical composition of raw materials (leguminous plants) and their modification during the processing and storage processes; V. Kokars analyzed the influence of barley microflora on the extraction of malt; I.D. Kārkliņa investigated the impact of yeast variety *Saccharomyces* on the quality of apple wine.

Besides the analysis of composition, processing and storage conditions of plant-based raw materials, researchers paid attention to the analysis of animal-derived raw materials. V. Rubene analyzed the quality of butter depending on the modes of physical maturation of cream; L. Ozola studied the influence of milk maturation in the process of milk coagulation and the quality provision

of obtained cheese; L. Skudra studied the influence of carbon dioxide on microflora of milk and its products; I.A. Skrupskis analyzed the influence of technological factors on the quality of frozen desserts.

The Department has provided the research laboratories with great scientific potential. The origins of research laboratories go back to 1971, when the Research Laboratory of Long-term Storage of Milk and Milk Products was set up (as a branch of All-Union Milk Research Institute). Prof. P. Zariņš supervised the research activities of senior scientific collaborators V. Šķiņķe, L. Skudra, V. Agafončikovs, and engineer J. Ņikitins. The Laboratory, initially established to satisfy the demands of milk production industry, focused on the research of milk product storage in the atmosphere of inert gases in the spray-type packaging. As research findings were not implemented in practice in food industry, the direction of research activities was changed and a rational application of by-products of milk production became one of the main Laboratory's activities. However, at the beginning of the 1990s, when the Laboratory equipment had become obsolete, it stopped functioning for a period of more than 15 years.

Research Laboratory of Barley for Beer, established in 1973 (as a branch of the All-Union Food Industry Research Institute), mostly focused on the technological features of beer hop species. The Laboratory staff included the head of the Laboratory, senior scientific collaborator K. Buivids, A. Jansons, V. Kokars, D. Golubeva, and Z. Veinberga, assistant prof. V. Šamarins, junior scientific collaborator A. Adamovičs, and senior laboratory assistant S. Ruisa. The researchers elaborated and defended several doctoral theses in engineering sciences. One of the first was the thesis on preparing and assessment of beer yeast pure culture defended by P. Zariņš (1949). In later years, the Doctor's degree was conferred on A. Daņiļevičs (1964), L. Ozola (1970), I. Āboliņa (1970), I. Melgalve (1972), E.V. Strautniece (1973), V. Kokars (1975), I.A. Skrupskis (1980), V. Agafončikovs (1982), and L. Skudra (1982). In 1971, P. Zariņš received the Doctor's degree in engineering sciences for his thesis on intensification of malt production technologies. During 1965–1975, two professors – P. Zariņš, Doctor of engineering sciences, and M. Pētersone, Doctor of biological sciences – worked at the Department of Food Product Technology.

Research Laboratory of Milk Products

On 1 December 1971, Pāvils Zariņš, head of the Department of Food Technology, opened the Scientific Laboratory of Milk and Milk Product Long-term Storage in Atmosphere of Inert Gases funded by the All-Union Milk Scientific Institute in Moscow. The small staff included: Līga Skudra – a micro-biologist and Head of the Laboratory, Vizma Šķiņķe – a chemist, and Vjačeslavs Agafončikovs, Jurijs Ņikitins, and Laimonis Zariņš – food technologists. The research was devoted to storage of fresh milk, condensed skimmed milk and whole milk in carbon dioxide (CO2) environment for extending the product's expiration date before its further processing. The team of researchers, later joined by Elizabete Reiņikova, a senior lecturer, and Imants Reiņikovs, assistant professor, developed several new products in aerosol packaging, for example, whipped cream "Mākonītis", "Paniņu kokteilis", and "Piena deserts", which were produced using nitric oxide (N2O), argon and nitrogen. All innovative products were tested in production conditions, leading to the defense of two doctoral thesis: Vjačeslavs Agafončikovs "Absorption of Carbon Dioxide in Liquid Milk Products", supervised by assistant professor Imants Reiņikovs (in 1981 in All-union Milk Scientific Institute in Moscow), and Līga Skudra "Impact of Carbon Dioxide on Milk and Milk Products Micro-flora", supervised by prof. Pāvils Zariņš (in 1982 in Voronez Technological Institute).

In 1979, when the Laboratory team launched new research on introducing non-residue technologies in milk processing factories, the Laboratory changed its name to the Research Laboratory of Milk and Milk Products. New researchers joined the team: scientific collaborators Marta Kalneniece, Dzidra Golubeva, Alla Jevlanova, Vija Ozola, Rita Ozoliņa, economist Dace Gailuma, supporting staff Lilita Kalnaraupa, Aina Skrabe, Lolita Valta, Tatjana Arsentjeva, Voldemārs Lipsts, Zinta Baltiņa, and Zigurds Pikšs.

The academic staff from the Faculty joined the Laboratory on part-time basis: assistant prof. Lija Dukaļska, Aleksejs Daņiļēvičs, Nikolajs Jansons, and Pauls Andersons. The research activities involved assistant lecturers Andris Miezītis and Ivars Rūvalds from the faculty of Agronomy, and undergraduate students Anita Miķelsone, Haralds Veteris and Uldis Rīgavs from the Faculty of Food Technology.

The research aim was processing of curds' whey, which resulted in the implementation of pickled condensed curds' whey production technology. Pickled condensed curds' whey was successfully used as a biologically qualitative additive and supplement of citric acid in several new confectionary products: chocolate candies "Mārīte", waffles "Sports" and "Zvaniņš", waffle cake "Kurzemīte", drops "Dagda", marshmallows "Malvīne". The above-mentioned confectionary products were launched by companies "Laima" and "Uzvara". Production of drops was implemented in the Lithuanian company "Rūta" and the Estonian company "Kalev". The drop production method was granted the certificate of authorship.

Pickled condensed curds' whey was applied in various products, for example, in rye bread and in dessert cream "Draudzība" produced in Riga and Tallinn milk factories. The use of pickled condensed curds' whey in baking rye bread accelerated the fermenting process of dough. Two new types of rye bread were developed: "Vidzeme" and "Jūrmala" (granted the certificate of authorship).

In addition, the Laboratory staff worked out technologies for whey drinks with various fruit juice additives for production of dry drink concentrate "Purenīte", inverted syrup, and spirit. The research was done on demineralized milk whey using it in developing new types of ice cream. Demineralization of whey with the help of electro-dialysis equipment was performed at the All-Union Milk Scientific Institute in Moscow and at the Ostankino Milk Factory.

Another trend was connected with the agriculture industry, where pickled condensed whey was applied for preservation of grain (granted the certificate of authorship), for making silo, as well as for feeding poultry – as a preventive measure against pullorosis. The researchers of the Laboratory worked out technology of a new product – lactate concentrate –, which was successfully used as a high quality additive to mixed silo. The research on lactate concentrate was reflected in Anita Blija's thesis "Technology of Dry Skimmed Milk Produced from Milk Whey Replacer", supervised by prof. P. Zariņš. Production of lactate concentrate in Aizpute Dry Skimmed Milk Factory was organized by Laimonis Zariņš and Mudīte Jomerte, who supported new innovative ideas and tested new technologies in production. The second new product with an elaborated production technology process was ammonized milk whey additive as a replacer of skimmed milk to the food of livestock. The testing of ammonized milk whey was implemented in the Training Farms in Sigulda and Vecauce.

The third direction in the application of pickled condensed whey was the branch of medicine, where nutritional supplements "Gastronorms" and "Osteonorms", developed in the Laboratory, were used by prof. Pēteris Gaudiņš from the Centre of Otolaryngology of the Republic Clinical

Hospital named after Pauls Stradiņš. The drugs were applied as a stimulator in patients for extraction of secretion in cases of low gastric acidity, or in cases when it was necessary to normalize intestine microflora after gastric and intestine operations in fistula patients. Besides, Dr. I. Rēvele from the Dentistry Department of the Riga Medicine Institute used this medicine to treat paradontosis patients with a dystrophic form of inflammation to improve their mouth hygiene.

The Laboratory research team (prof. P. Zariņš, head of the Laboratory, assist. prof. L. Skudra, senior scientific collaborators V. Agafončikovs, M. Kalneniece, assist. prof. L. Dukaļska) as well as representatives of the factories (Mudīte Jomerte, Aivars Jākobsons, Apolonija Pelše, Ivars Rudzītis, Antoņina Samulēviča, Uldis Ramanis, Ēvalds Gribuška) were awarded the Latvian State Prize in Science and Production for "Non-Residue Technology for Producing Curds and Cheese" in 1987.

Department of Power and Heating Engineering

The Department of Power and Heating Engineering was established in 1945, and was included in the newly founded Faculty of Food Production Technology.

The founder and head of the Department for many years (1945–1973) was prof. Jānis Āboliņš, Honorary Employee of science and technology, a holder of National Prize, Doctor of engineering sciences. He was followed by prof. Ernests Jurevics (1973–1984 and 1990–1993), when the Department was joined to the Department of Food Technology. In the time period from 1984 until 1989, the Department was headed by assist. prof. Zigurds Egle, Doctor of engineering sciences, who studied the quality of technical oils and elaborated the method for checking oils.

In the 1980s, the Department's staff comprised seven lecturers, three laboratory assistants, as well as nine scientific collaborators and employees of the Laboratory of Hydrothermal Processing.

Prof. Jānis Āboliņš founded and headed the Research Laboratory of Agriculture and Technological Hydrothermal Processing (former Laboratory of Rational Use of Energy in Processing Agriculture Products since 1989) at the Department of Power and Heating Engineering. The lectures were delivered by assistant professors Arturs Gružāns, Pēteris Zeltiņš, and Nikolajs Brakšs, assistant lecturer Zigurds Egle, and senior lecturers Sergejs Solovjovs and Teodors Jankevics. When the Faculty of Food Production Technology moved from Riga to Jelgava in 1960, several young specialists left their jobs in factories and became researchers and lecturers at the Department of Power and Heating Engineering: Ernests Jurevics, Lija Liepa (Dukaļska), Imants Reiņikovs, Aleksejs Daņiļevičs, Gunārs Brēmers, and Laima Dālberga. Later also Zaiga Vēja, Ruta Galoburda, Elīna Sturmoviča, and Uldis Rīgavs joined the Department. Actively involved in the scientific work were the doctoral students (Harijs Žīgurs, Silvija Dālmane, Jānis Dolacis, Imants Šūmans, and Jānis Laže) and several engineers and scientific collaborators (Zigrīda Liepiņa, Fricis Spilva, Zaiga Vēja Modris Ķevers, Laima Dālberga, Auseklis Jansons, Elīna Sturmoviča, Kārlis Tomsons, etc.). For many years, the support staff members were Fricis Dālmanis and Alberts Rube.

The core study courses of the Department were: Heat engineering, Thermodynamics, Processing equipment, Food production technologies, Cold engineering, Work place security, Fuel and oiling materials, Patent science, Automatic business management, Hydraulics. The academic staff of the Department supervised the Practice of technology application, as well as Elaboration of course projects and diploma projects. The Department provided training in Heat engineering, Thermodynamics, and Fuel and oiling materials for the students of the Faculties of Forest

Engineering and Agriculture Engineering. The main research interest was the heat power and product hydrothermal processing issues (Brēmers, 1998). The group of researchers, supervised by prof. J. Āboliņš, carried out research on desiccation processes of various substances. Certificates of authorship were granted for various technical solutions. One of the cutting-edge innovations was the first permanent malt drying kiln (LLA–5, LLA–10, and LLA–20), which reduced the malt preparing time and the heat consumption, as well as improved the malt quality. The authors of the inventions were J. Āboliņš, P. Zariņš, and P. Zeltiņš. The certificate of authorship was granted for the invention of the drying kiln for production of vitamin-rich flour from the green mass by means of a fast-drying method. The flour was produced from the leaves of trees as well as from needles of both spruce and pines during winter wood cutting. Such flour contained carotene and other biologically active substances and was added to fodder and food produced for chicken, pigs, and poultry.

Assist. prof. P. Zeltiņš investigated the use of the wind power in drying agriculture products, for which he received the certificate of authorship in 1955. He researched the design and construction of a permanent fast drying-kiln for milk protein, where the product dried in 1–3 minutes. This type of kiln was used for drying medication and biologically active products.

Under the supervision of prof. J. Āboliņš, doctoral students studied the drying processes of various products. For example, Imants Reiņikovs worked out the thesis on drying of sour milk products in a sublimation drying kiln, as well as created a permanent aerodynamic starch drying kiln, where products dried in 30 seconds, instead of 2–10 hours. Ernests Jurevics studied drying methods of sugar paste (sugar production by-product – filter lime); Jānis Laže worked out the thesis on drying fine sugar in a vibrating–simmering layer; Imants Šumanis worked out the thesis on dehydration of casein in aerofonane drying kiln. The experimental equipment for the researches was designed, constructed and made by the researchers themselves.

The Laboratory staff had worked out drying kilns for drying of various products, such as yeast, starch, apples and other fruit, hop, nuts, pollen, herbs, casein, penicillin (Danga, 1993). Satisfying the demands of confectionery producers, a brand new permanent cone drying kiln for extracting the seeds from spruce and pines, as well as a permanent-operation fast-grinding machine for seeds of cannabis and sesame were designed.

Under the guidance of professors J. Āboliņš and E. Jurevics, the Department of Power and Heating Engineering has carried out extensive research on heating processes and energy consumption in agriculture and food processing technologies, on development of a new kind of fuel and its use in agriculture, and on alternative methods of heat production – the use of the earth heat in heating of buildings.

The doctoral students were actively involved in the research process. Lija Liepa (Dukaļska) studied the hydrothermal processes and energy consumption in agriculture equipment, whey vaporization, and use of whey in food as well as for production of new type of fodder. At present, prof. L. Dukaļska is working on brand new packaging methods and on application of biopolymers in food industry. She has been awarded the degree of Doctor habil. in engineering sciences.

Aleksejs Daņiļevičs studied the intensification process of new types of thermal processing of various granular agriculture raw materials. Harijs Žīgurs elaborated his doctoral thesis on the effect of location of heat generators on pure rye bread baking process.

The research on the bread baking mechanization process and the improvement of baking quality was continued under the supervision of prof. J. Āboliņš by designing projects of mechanized rye

bread baking kilns heated by electric power, which have become widely used by the small bakeries in Latvia.

Zigurds Egle's doctoral research theme was a new type of furnace fuel in agriculture heating equipment; Silvija Dālmane defended her thesis on technical parameters of apples and their alteration during storage.

The researchers of the Department studied the storage of other products as well. For example, a group of scientists under the guidance of J. Āboliņš analyzed the methods of decreasing the losses in the storage of potatoes (Danga, 1993), and Gunārs Brēmers carried out research on intensification of alcoholic fermentation processes.

The research directions initiated by the Department of Power and Heating Engineering are being continued by Ruta Galoburda, who started her scientific activities during the undergraduate studies elaborating her bachelor thesis on whey concentrate desiccation. After graduation, she started her carrier as a senior scientific collaborator of the Department of Power and Heating Engineering at the LLU. She defended her doctoral thesis "Transportation and Pre-packaging Storage Parameters and Conditions of Dry Skimmed Milk and Dry Whey" in 1993, after the Departments of Power and Heating Engineering and Food technology had been merged. In recent years, R. Galoburda has been involved in the elaboration of food processing terminology and in the research of the impact of various technological processes on food quality.

Grain drying kilns and grain storage reservoirs (the latter together with A. Vilde), introduced by the Department of Power and Heating Engineering, are typically applied in Latvia. According to Timšāns *et al*. (1993), several research projects, worked out under the guidance of prof. J. Āboliņš, have been implemented not only in Latvia but also in countries of the former Soviet Union as well as in other countries (Albania, Cuba). Malt drying kilns, designed in cooperation with P. Zariņš and P. Zeltiņš, have been introduced in approximately 90 locations (Russia, Ukraine, Georgia, Latvia, Albania, and Cuba). The technology and equipment for producing needle and grass flour are applied in Latvia, in different places of the former Soviet Union, and in other foreign countries. Cone drying kiln has been designed for obtaining seeds of pines, spruce, cedars and larches in cooperation with A. Lulle. A new type of fuel has been tested and introduced from oil processing intermediate products, the so-called combustible fuel (TPB) that was widely used in agriculture and in heating of Līvāni-type houses. Technical specifications of this kind of fuel were elaborated in the Department. The patents and certificates of authorship have been awarded for the majority of innovative equipment, methods, technologies, and devices, the number of which exceeds 30.

The academic staff of the Department of Power and Heating Engineering have published more than 400 scientific papers and brochures and have written several course books, for example, "Engineering Thermodynamics" (J. Āboliņš, 1946), "Exercises in Thermodynamics and Heating Engineering" (J. Āboliņš with co-authors, 1948), "Primary Processing and Storage of Grain" (J. Āboliņš, 1961), "Fuels and Oils. Materials of Exploitation of Tractors and Automobiles" (Z. Egle, 1967), "Cold Engineering" (I. Reiņikovs, E. Jurevics, 1972), "Heat in Industry and Households" (J. Āboliņš, E. Jurevics, 1986), "Daily Bread" (Z. Liepiņa, 1993).

Department of Food Technology

In 1993, the Rector issued the decision to merge the Departments of Food Product Technology and Power and Heating Engineering and to establish the Department of Food Technology. The

change of the name did not alter the intensive scientific work. Seven members of academic staff defended their doctoral theses during six years and were awarded the engineering scientific degree – Dr.sc.ing.: assistant professors D. Kārkliņa (1993), R. Galoburda (1993) and A. Blija (1995), and lecturers O. Rubenis (1997), I. Ciproviča (1998), E. Sturmoviča (1998) and D. Kunkulberga (1999); assist. prof. L. Dukaļska was awarded Dr.habil.sc.ing (1997).

One of the first laboratories established after the revival of independence of the Republic of Latvia is the Laboratory of Sensory Analysis of Food Products (2000). For many years, the Sensory Evaluation Laboratory, created by prof. E. Strautniece, is a part of the Department. The Laboratory services are used by students, by postgraduates, and partly also by doctoral students if their research work is related to creating a new food product or storing of food products. The Sensory Laboratory is in use already for several years, and always when research is dealing with the development of storage of new foods, sensory analyses are applied. Sensory evaluation in this Laboratory generally has been carried out by undergraduates and master degree and PhD students.

From the year 2004 to 2009, technological equipment of the Department has been greatly improved thanks to the European funds. In 2005, the Laboratory of Analysis of Packaging Materials was opened using the ERAF funding for renovation and modern equipment.

In 2006, the Research Laboratory of Microbiology was renovated and supplied with modern equipment, which was financed by the Project "Establishment of Laboratory of Material Radioactivity and Hygiene" of the Ministry of Economics of the Republic of Latvia. The Laboratory used the premises of the previous Research Laboratory of Long-term Storage of Milk and Milk Products.

In 2007, three new research laboratories were opened after renovation and installation of modern equipment. They were: the Research Laboratory of Bread Analysis, the Laboratory of Food Processes and Technologies, and the Laboratory of Food Product Analysis. Due to additional funding it was possible to capture the memory of prominent prof. Jānis Āboliņš, the former head of the Department of Power and Heating Engineering; one of the auditoriums was named after his name. In addition, the tradition of the Latvia University of Agriculture to announce the awards named after seven prominent LLU scientists was established in 1996 according to the decision of the Senate. One of the awards in Food Product Technologies was named after prof. J. Āboliņš.

The research of the Department during the last fifteen years has expanded. The following research activities have been implemented: baking qualities of flour, and improvement of bread quality; development of new food products, including functional food products focusing on the improvement of their nutritive value and functionality; packaging of food products using various materials and technologies; analysis of bio-agriculture raw materials; analysis of safety and harmlessness of raw materials and food products. It was possible to implement the above-mentioned researches with the assistance of funding offered by the Scientific Council of Latvia, the national programmes, and international projects. New laboratories, modern equipment, renovated premises for classrooms and staff rooms, ERAF financing opportunities for doctoral students – these were the main preconditions for elaboration of research papers. Thus, during the last six years, eight members of academic staff have been awarded the Doctor's degree: Dace Kļava (2003), Solvita Kampuse (2006), Sandra Muižniece-Brasava (2006), Tatjana Rakčejeva (2006), Evita Straumīte (2006), Ilze Grāmatiņa (2007), Jeļena Zagorska (2007), and Zanda Krūma (2008).

The overview of the Department's research activities shows that the most important ones were carried out on the basis of the projects of European 5th Framework Programme: EcoPac,

QLRT-2001-01823 "Recyclable and Biodegradable Eco-Efficient Packaging Solutions for the Food Packaging"; "Quality of Life and management of Living Resources" (LIFE) (2002–05, www.eco-pac.com); PackTeck, Contract N G1RTC-CT-2002-05068 "Assimilation and Standardization of Environmentally Friendly Packaging Technologies within the Food Industry" (2002–05, www.pack-teck.org); and the project of the 6th Framework programme SAFEFOODNET FOOD-CT-2004-513988 "Chemical Food Safety Network for the Enlarging Europe" (2005-06).

The projects gave an opportunity to have a fully-fledged participation in the topical issues on the food research in European dimension, exchange experience, and acquire new contacts. The achievements in food research by the academic staff of the Department of Food Technology have been noted by various awards and honorary titles of the state. Professors P. Zariņš (1996), L. Dukaļska (2003) and L. Skudra (2008), and assist. prof. L. Ozola (2006) have been awarded the title of Emeritus. Professor D. Kārkliņa has been awarded the Great Award of Science (2001) established by the company "Aldaris" in cooperation with the Scientific Council of Latvia. Professor P. Zariņš received the award of the Cabinet of Ministers of the Republic of Latvia for his contribution in food science and in training of food industry specialists (2008).

Department of Nutrition

On 1 September 1989, the Popular Front of Latvia (LTF) and Latvian Culture Foundation (LKF) proposed, LLU authorities approved, and the Faculty of Food Industry Technology (PRTF) renewed the training of specialists in the field of home economics. The traditions continued, and, instead of Kaucminde manor, where the first housekeepers were trained, the palace of Valdeka became the place for training students in home economics. In 1989, the Department of Nutrition and Apprenticeship was established to prepare specialists in home economics. In 1993, the Department of Nutrition and Apprenticeship was renamed the Department of Nutrition and Home economics. In accordance with the goal-directed Model of Human Life and Activity, educational goals were to master housework for reaching better living conditions and economical welfare, and to master the production of domestic values and economical estimation of this activity. The integrated consumers and householders' sciences, family needs and domestic problems, handicraft and handiwork skills were fundamental to systemise education in home economics faced only with two educational or scientific aspects – Household, and Housekeeping. A methodological link between the Home Economics and the subjects of the sciences had to be studied on the level of structural elements, i.e., to form the standpoint of the systemic approach and the method of scientific research.

In 1993, the first contest in Home economics was organized, followed by ten others; on 18 April 2000, the 1st International Baltic Olympiad in Home economics took place. The Department contributed a lot to organizing international conferences. Thanks to the excellent organizational work by associate professors Vija Dišlere and Ruta Galoburda, the international scientific conference "Development areas in today's home economics" took place in LLU in 1995. In September 1998, the international conference "Current issues of training in home economics" was organized and devoted to the 60th anniversary of the foundation of Latvia Home Economics Institute and to the 110th anniversary of the long-term headmistress Olga Stakle Kulitane.

After 10 years of work, the Department of Nutrition and Home economics was closed, but on 1 July 2000 the new Department of Nutrition started its work, separating from the

Department of Nutrition and Home economics. Students and professors of Home economics programme were included in the new Institute of Education and Household of the Faculty of Engineering.

Scientific research field of the Department of Nutrition is related to foodstuff production. The scientific work presented by the Doctors of Science of the Department are:

Imants Skrupskis – Artificial cold for quality preservation of fruits, berries and vegetables (1996). He was the first to be awarded the degree of Doctor Habilitatus at the Faculty after the establishment of the new Scientific Councils at the LLU;

Kauliņš Uldis – Nutritional problems and their solution in Latvia (1996; scientific supervisor – assoc. prof. I. Melgalve);

Rozenbergs Viesturs – Possibilities of Japanese Quince Use in Confectionery (1998; scientific supervisor – prof. I. Skrupskis);

Ruciņš Mārtiņš – The possibility of black currant berries using in food industry (1998; scientific supervisor – assoc. prof. I. Melgalve);

Solvita Kampuse – Suitability to freezing of berries from different raspberry, black, red and white currant cultivars grown in Latvia (2006; scientific supervisor – prof. I. Skrupskis);

Ilze Beitāne – The evaluation of lactose and inulin for the development of a new functional milk product (2008; scientific supervisor – assoc. prof. I. Ciproviča);

Tatjana Marčenkova – Microbiological criteria for ready-to-eat foods (2010; scientific supervisor – assoc. prof. M. Ruciņš).

During 2004–2007, assoc.prof. M. Ruciņš supervised scientific work under the following issues: M. Landmane – Meat products cooked in low temperatures; A. Klimovs – Product quality changes cooked in microwave oven; and A. Strazds – Quality of cleaning and disinfection detergents in catering services.

The research work is continued by doctoral and postdoctoral students: S. Boča – "Factors influencing fruit dessert quality"; R. Riekstiņa–Doļģe – "Suitability of apples grown in Latvia for production of fermented beverages"; and J. Ķīvīte is doing research on ostrich meat and its chemical composition, and compares it with beef and poultry.

However, the issues of research have expanded into the management of hospitality establishments. Identification of factors influencing the production process in catering industry is one of the research problems based on detailed analysis of the operation and management of the catering enterprise. The solving of topical industrial issues will help employees understand the operational process in hotels and catering enterprises. One of the most relevant aspects, which are being solved at present, is the quality of personnel: in 2009, I. Millere defended her Doctor's thesis in economics "The activity processes in catering business in Latvia's regions"; a year later, in 2010, L. Medne defended her Doctor's thesis in sciences of economics "Quality of personnel resources of hospitality enterprises in regions of Latvia".

The scientific research fields at the Department of Nutrition are:

- problems of hotel management and organization (assist. prof. L. Medne);
- problems of management and work organization in catering enterprises (assoc. prof. A. Blija, assist. professors I. Millere and L. Medne, lecturer S. Īriste);
- factors affecting the quality of service (assoc. prof. A. Blija);
- research of food manufacturing, packaging, preservation (prof. I. Skrupskis, assist. prof. V. Rozenbergs, assoc. prof. A. Blija, lecturers J. Ķīvīte and G. Skudra);

- IT softwares for promotion of efficiency in hospitality enterprises (assoc. prof. M. Ruciņš);
- quality of personnel in hospitality sector (assist. professors I. Millere and L. Medne, lecturer S. Īriste).

Participation in scientific projects and market research

In the past years, teaching staff of the Department of Nutrition has gained significant experience whilst accomplishing several European-funded projects side by side with researchers from various institutions of European countries. The main fields of projects where the Department lecturers have worked are the following:

- development of guidelines for personnel in hospitality industry;
- labor market advancement, also integration of hospitality industry in EU labor market;
- research of consumer issues; issues of society integration;
- using up-to-date technologies for business progress
- issues on improvement of storage and processing processes of food products; issues providing food safety;
- development of new food products and technologies.

Scientists have patented their inventions. During 2008–2012, three Latvian patents and one European patent, which is the first in the LLU, were registered.

Department of Chemistry

The Department of Chemistry was included in the Faculty of Food Processing Technology in 1948. The Department of Chemistry and Soil Science of the Faculty of Agriculture at the Latvia University College (headed by P. Kulitāns) can be considered as a predecessor of the Department of Chemistry. Until 1948, the Department of Chemistry was included in the structure of the Faculty of Forestry thus influencing several scientists of the Department to focus their research on wood-pulp chemistry. From the moment of inclusion of the department in the new Faculty, it was required to supervise the research work of the Faculty's students. There were enthusiasts among the students who in cooperation with lecturers carried out research without signing a contract (it was not a practice then) and without receiving payment (assist. prof. Gunārs Brēmers, academician Mārtiņš Beķeris, etc.). The research carried out at the Department of Chemistry on extraction of yeast from molasses distilling-mash was implemented in manufacturing – a yeast production unit was built in Mīlgrāvis Spirit Factory.

Wood acetylation researches

The study of wood acetylation was initiated by Kārlis Švalbe, professor of the Department of Chemistry (1912.09.04.–2002.11.27.). Initially, he studied wood protection with different inorganic compounds and came to the conclusion that protecting wood with compounds containing non-renewable elements – chromium, copper, and arsenic – is not the right method. At the end of the 1960s, his research interest was wood acetylation. Prof. K. Švalbe and his co-workers investigated acetic anhydride, acetic acid, ketene, diketene, anhydrides of mono- and dicarboxylic acids as acylating reagents with different acetylation schedules for solid wood and wood fibre acetylation in liquid and vapour phase with and without catalysts. Extensive investigations into acetylated wood to determine its mechanical, hydrophobic properties, dimensional and biological stability, as well as glueability were carried out. The laboratory-scale results of wood acetylation were transferred to pilot-scale tests at the Krylov Central Scientific Research Institute in St.Petersburg (former

Leningrad) that provided acetylation of actual-size (up to 3 m long) timber. Professor Kārlis Švalbe was the first in former Soviet Union who adventured to begin wood acetylation first in laboratory scale and then realised it in the pilot scale (Morozovs *et al*., 2003).

Investigations on wood modification and wood performance characteristics determination are in progress at the Department of Chemistry.

When Kārlis Švalbe began working at LLU in 1946, after Arvīds Kalniņš' suggestion, he focused on the issue of wood protection. In 1949, he defended his Doctor's thesis "New wood antiseptics in Soviet Latvia conditions" and was awarded the degree of the Candidate of Technical Sciences. The following years he continued his research according to the traditions of wood protection of that time – examining wood protection chemicals for the lowest prices. K. Švalbe found out the usefulness of selenium and its compounds in protection of wood. Together with Imants Reiņikovs, they determined that cadmium compounds had some fungicidal qualities, which could be suitable for chemical protection of wood. Besides, together with scientific collaborator I. Alsups, K. Švalbe clarified the capabilities of cadmium chromate and cadmium oxide in chemical protection of wood. In cooperation with E. Dunkelis and I. Alsups, K. Švalbe found out that maleic hydrazide can be useful in chemical protection of wood; they engaged in more intensive studies and came to the conclusion that wood acetylation could be a feasible method in wood protection.

In 1968, I. Ozoliņa defended her thesis for the degree of the Candidate of technical sciences. She found the acetylation key figures by acetylating the pine (*Pinus sylvestris*) wood samples of different sizes. It was ascertained that the acetylation degree was at least 20% even after sustained elution tests. I. Ozoliņa received royalty for this research.

I. Karlsone began wood acetylation researches with a notable enthusiasm, and, within a year – in 1974, she defended her doctoral thesis for the Candidate of technical sciences degree. In her researches, she briefly explained the opportunity of utilizing keten. It was the first work on wood acetylation with this very active matter.

The scientists and technologists of the Krylov Central Scientific Research Institute became interested in LLU's research work on wood acetylation, and in the 1970s they expressed their willingness to cooperate with LLU scientists to achieve form-stable wood by using the acetylation method. It should be pointed out that the Department of Chemistry won the first prize not only in the USSR, but also at international level.

After the researches carried out at the LLU Department of Chemistry, the Latvian Biochemical Institute started using acetylation remainder for production of lysine, which was significant in raising the economic effect of lysine production. Consequently, Latvia had a real opportunity to produce acetylated wood on an industrial scale.

M. Kūka's researches (not including publications and the certificate of authorship) on wood fibre acetylation were compiled in her thesis "Wood fibre chemical modification with acetic acid anhydride", which was defended in 1993. Treating the samples from the Bolderāja complex wood processing company with acetic acid anhydride, both liquid and gaseous form, the parameters of wood fiber acetylation were obtained.

In the 1960s, when research on wood acetylation methods was undertaken, there was disbelief in the future of this method even among the scientists.

K. Švalbe's investment in the research of wood acetylation, firstly, was organizing work for development of the five above-mentioned theses. Studying scientific publications on

wood protection, the idea originated that it could be possible to prevent imperfections in exploitation of wood (although some nature scientists believed that chemists only damage the wood with chemicals).

The increasing demand for wood as well as the social role of forests will be in harmony with environmental requirements, leading to a new way of producing materials and goods involving the long-term use of resources that do not damage the environment.

Acetylation of solid wood with acetic acid anhydride and other acylating reagents was started at the end of the 1960s. The reactivity with different acetylating reagents had been studied in ten wood species grown in Latvia. Potassium acetate and magnesium perchlorate were tested as a catalyst. Wood treatment with dichloromethane, water, and high-frequency current was studied to increase acetylation degree of wood. Bench-scale trials with various reagents and solvents were performed to fix or to extract residual acetic acid from solid acetylated wood. The mathematical modelling of acetic anhydride diffusion in wood was used to study the reaction kinetics determinative factors on macroscopic scale. Enhancement of hydrophobic properties of acetylated wood with plant oil ethyl esters was tested. Water vapour absorption dynamics and liquid water up-take were used to estimate alteration of hydrophobic properties of treated wood. The main impact in reduction of wood swelling was attributed to acetylation, butin in respect of water absorption – to impregnation of acetylated wood with seed oil or its ester. Direct impregnation of wood with vegetable oil or ester without acetylation had less effect on reduction of water absorption and swelling. Laboratory trials resulted in designing, making up, and putting in action pilot equipment of solid wood acetylation with acetic anhydride in liquid phase in the 1970s. Timber up to three meters long could be acetylated with the pilot equipment. Action to fire, hygroscopic properties, as well as surface free energy assessment are in research agenda of suitable application of timber and modified wood in constructions and products currently at the Department of Chemistry.

N. Jansons, K. Švalbe, M. Dūdiņš, B. Vimba, E. Lapsa, L. Neilande, R. and I. Streipas, I. Ozoliņa, P. Andersons, U. Kauliņš, J. Sauka, J. Jansons, Dz. Dambe, and L. Vecmuktāne worked as chemists and pedagogues in good faith during these years. In the implementation of the scientific and study work, took part the head of the Laboratory Guna Aprāne, scientific collaborator Astrīda Rugēvica, and Laboratory assistants Rūta Āna, Ausma Embrekša, Inta Granta, Sarma Jurēvica, Vija Kreicuma,Valda Markota, Māra Fišere, Olita Zariņa, Aina Voicehovska, and Brigita Alberta.

In 2006, the modern Research Laboratory of Natural Substances with up-to-date equipment, funded by ERAF project, was opened. The Laboratory possesses highly-effective liquid chromatography with the separation and diagnosis function of such substances as amino acid, carbohydrates, antioxidants, organic acid and other compounds existing in food products of plants and berries. Assoc. professor P. Kūka, leading researcher F. Dimiņš, assistant lecturer I. Cinkmanis, assistant professors M. Kūka and I. Čakste are engaged in various research projects. The project "Assessment System of Wood-pulp Surface Characteristics and Compatibility with Other Materials" (2005–2008) was implemented by I. Čakste, F. Dimiņš, P. Kūka, A. Morozovs, and E. Muzikante. Within the framework of the above-mentioned project, the Research Laboratory of Wood-pulp Modification and Surface was established and supplied with valuable wood-pulp research equipment.

Elimination of the lack of albumen in fodder was studied under supervision of assist. prof. N. Jansons; since 1954, the chemical characteristics of sapropel and its usage opportunities in

agriculture were studied under the guidance of assist. prof. B. Vimba. This research was continued until the end of the 1980s by M. Dūdiņš, B. Druviete, and D. Truksne. Assist. prof. I. Streipa carried out research on the microelements (iodine and bromine) in plants and soil.

The wood pulp modification studies have been carried out by prof. K. Švalbe since 1964, resulting in tens of certificates of authorship, elaboration of a doctoral thesis, and implementation of the results in practice. The scientific work by K. Švalbe was continued by assoc. prof. A. Morozovs. Since 1960, application of biologically active compounds in agriculture has been studied under the guidance of prof. P. Andersons. The research supervised by assist. prof. U. Kauliņš was connected with the analysis of the physiological value of food. Assoc.prof. A. Morozovs led the research on the characteristics of wood pulp surface and worked out scientific substantiation of the complex use of the raw materials of renewable resources; in addition, A. Morozovs focused on the chemical composition of alternative fuel.

The research fields of other teaching staff members are connected with food. P. Kūka was engaged in research of water quality, and in co-operation with F. Dimiņš – also in the study of honey quality and its alternative quality data; V. Kreicbergs, M. Kūka, V. Miķelsone, and B. Ozola studied chemical substances and their modifications, as well as antioxidant features of agricultural and food products; A. Veršilovskis, under supervision of V. Miķelsone, studied the content of sterigmatocystin in cereals; Z. Krūma investigated the extraction of volatile compounds from herbs, and of phenol from oil; I. Čakste investigated the quality of food product packaging; M. Kūka and A. Bluka studied the quality of oils produced in Latvia; M. Dūma studied the content of selenium in raw materials and products; and I. Cinkmanis researched the production of unconventional beer.

During the last 15 years, the research activities have resulted in five defended doctoral theses (M. Kūka, U. Kauliņš, O. Rubenis, V. Miķelsone, and F. Dimiņš), which makes a 67% share of the academic staff with a doctor's degree. The Department of Chemistry has cooperated with the Department of Food Technology and has supported elaboration and defense of doctoral theses by E. Straumīte, I. Grāmatiņa, and Z. Krūma. At present, seven doctoral students and post-doctoral students are elaborating their doctoral theses at the Department of Chemistry.

The end of the 20th century at the Faculty of Food Technology

As the beginner of the scientific research at the Department of Chemistry can be considered prof. P. Andersons, who already in the 1970s began to study animal growth promotion with the help of chemical compounds. In his research, prof. P. Andersons cooperated with the Institute of Organic Synthesis and the factory of *Chemical Reagents* of *Olaine*. In the middle of the 1980s, a contract group (scientific supervisor I. Melgalve) that dealt with complex food research problems and development of new recipes was formed. The work was organized jointly with manufacturers and with institutes of the Latvian Academy of Sciences, involving employees of the Department of Chemistry and other departments. One of the most important tasks was to reduce the quantity of feedstuffs in fodder intended for non-food companies, and the complex use of these feedstuffs. For example, for production of the enzyme lysozyme, the factory of *Chemical Reagents* of *Olaine* should use more than one million chicken eggs per year, discarding the production residue landfill. LLU developed a completely new, original *acid method* for obtaining lysozyme (Микелсоне и др., 1986; Каулиньш и др., 1992), as well as a new recipe of sausage production by adding egg white and yolk residue in liver sausages after removal of the oils (M. Āboltiņš).

Besides, manufacturers were offered a feed additive for fur animals, obtained from chipped eggs in poultry factories for the complex production of immobilized trace elements with lysozyme

as an immunostimulant activity (J. Latvietis *et al*., 1998). A similar work was organized on the use of Japanese quince, which began with studies on dependence of acidity content on climatic conditions. Together with professionals from Riga citric acid factory, the quantity and composition of carbonic acid was determined, providing theoretical ground on the advantage of carbonic acid complex (U. Kauliņš *et al*., 1998) in comparison with the traditional products containing citric acid. The research suggested that Japanese quince fruits improved organoleptic properties of other fruit and berry products (J. Lipska *et al*.), and they could be used for production of high-quality candied fruits (D. Seglina, U. Kauliņš, 2001), but frozen Japanese quince fruits and fermented juice (wine) from them were of very low quality (I. Sandelāne *et al*.).

Actually, working with processing agricultural products, the whole research cycle for obtaining–storage–processing–production of food additives, as well as possibilities of using production waste, were followed.

As prof. P. Anderson's research interest was livestock problems, he created the original biologically active feed additive classification (P. Anderson, 1995); to solve some issues, he involved also the staff of the Department (L. Vecmuktāne, I. Brante, 1995; O. Rubenis, 1995), as well as collaborated with other departments, including the Department of Animal Feeding (J. Latvietis, L. Kārkla *et al*.).

Besides the intensification of agricultural production, also quality improvement was considered. For example, as Latvia lies in a selenium-poor soil zone, the possibility of increasing amount of the microelement selenium in vegetable products was examined (I. Strokša, M. Dūma *et al*., 2000).

Storage of the obtained production is very important.

In practice, lysozyme containing solution was tested in coating apples for long-term storage of local sorts, and it showed good results (I. Skrupskis *et al*., 1991); technologies of freezing strawberries (I. Melgalve, I. Skrupskis *et al*.) and black currants (M. Ruciņš *et al*., I. Melgalve, 1998) were worked out.

To this sub-group can be added cultured drinks with extended shelf-life by preservative additive from cereals (L. Line *et al*., 1998).

In researches, high school chemistry teachers and senior students were involved – for screening that cannot be done by the teaching staff and scientific group members because of the lack of time.

In the experiments with apple storage, Lielvārde high school participated (chemistry teacher V. Gobiņa). Some interesting observations on the preservation of cut flowers were made in Suntaži high school (M. Maskava; chemistry teacher L. Caune). Preservation of forage grain without the use of chemical preservatives (P. Anderson *et al*.), which would reduce the loading of grain dryers in harvesting season, was tested in laboratory conditions. Very versatile is the range of using food and the development of new recipes, covering a number of branches. Here can be noted few patented products or technologies, such as the above-mentioned use of Japanese quince (V. Rozenberg *et al*., 1998), as well as use of absolutely new raw materials for obtaining already familiar products with different organoleptic properties, such as flavourless carotene extracted from lily pollen (L. Parādniece *et al*., 2000), and development of carotene with a specific aroma and taste from pollen collected by bees (L. Līne, 2000) for colouring and flavouring of food products.

In the food additive group, a new technology for extracting some aromatic substances and concentrates from natural products, such as caraways (E. Meijere, A. Sedvalde, A. Strode *et al*.) was developed, and flavoured sugar was obtained (R. Bunduls).

With the development of production, also production of waste is increasing. Often, production waste can be used as fertilizer and bioactive additive in animal husbandry (P. Andersons), and as raw material for obtaining other products.

In cocoa bean recycling process, bean skins ("kakao vella") with cocoa powder-like flavour are generated as a waste product. Using it as a substitute for cocoa beans, recipes with truffles and ice cream "*Cacao Vella"* additives were made (L. Kalniņš *et al*.), and biological activity of the product was tested (Озола Б. и др., 2003).

In some cases, by introducing a complex recycling of raw materials and using a semi-finished product, it is possible to have no industrial waste at all.

This is very important using edible products in non-food industry, such as production of biochemical preparations which have already been mentioned in connection with the production of lysozyme.

Numerous studies, such as the formation of peroxide in food (B. Ozola *et al*.), became the basis for the preparation of training guides (U. Kauliņš, D. Kārkliņa, M. Dūma, 2000; U. Kauliņš, B. Ozola, I Melgalve, 2003) or were used for publishing more extended reviews (I. Melgalve, 1993).

Work of the Research group of the PTF Chemistry Department was provided by government grants, and by the customers – collective farm "Valgunde", Iecava poultry factory, collective farm "Līdums".

Contractor working groups in the course of the work received 19 USSR authorship certificates, and 13 Latvian and three Russian patents; three rationalization proposals were introduced.

Research achievements were presented in more than 150 scientific publications and 57 posters; lectures were delivered also abroad.

In 1991, the main research fields were: The new technology of foodstuffs, Chemical properties of raw materials for food, Utilization of products, and Storage and processing of agricultural products.

In 1993, an international assessment of research projects was carried out by Danish experts. Their point of view about the Research Council's grant project "Storage and processing of agricultural products" (assist. prof. Imants Skrupskis, senior scientist Uldis Kaulins) was:

"The research project "Storage and processing of agricultural products" are product-oriented with the aim of developing new products, or raw materials for products. It is not possible from the descriptions to get an idea of how many resources are used for the different subjects. It seems that the main part is used for vegetable products. One subject deals with technology for production of fruit juices, blackcurrant concentrated juice, and storage of fruit juices at controlled temperature. Another subject is research in hydrolysis of starch from potatoes, but was not planned to find new methods of production or methods of measuring the hydrolysis process.

Within the animal sector production of special products from eggs:

Egg oil and lysozyme has been developed, but research with meat or meat products were not in the research plan of the Department. A taste panel was only used for the final products when some comparative testing was carried out.

The main access to literature was abstract collections in Russian language, and it was difficult or impossible to get original articles from international journals.

In the development of new products, a two-step procedure is performed:

a) product development and recipe description in the laboratories of the Department;
b) large-scale testing in big farms (collective farms) and agrofirm "Ķekava".

For the subject of fruit juices and non-alcoholic wine, the Department has established cooperation with the Institute of Non-alcoholic Drinks in Moscow."

In 1998, for the first time, elections of State professors and Associated professors took place, and an international commission of experts examined the applicants' work. For the confirmed 58 vacancies of professors, 27 professors were elected. At the Faculty of Food Technology, Imants Skrupskis and Lija Dukalska were elected. It should be noted that L. Dukalska had defended her Habilitation thesis and was positively evaluated by the international expert (prof. Braen Makenna from Ireland). With this, a new period started also in assigning the position of a university lecturer, where research work is of great importance.

Arrangement of research facilities at the Faculty of Food Technology

During the last decade, the equipment and measuring devices have been purchased thanks to the support of various European funds and other financial resources.

In LLU, the first laboratory established with the support of the European Regional Development Funds (ERDF) was the Laboratory of Packaging Material Property Testing, officially opened in May 2005. The Laboratory was created mainly with the aim to modernize the study process of PhD students in food science; today there have been accomplished master and bachelor thesis as well.

The Research Laboratory of Microbiology is another newly equipped facility arranged thanks to the support from the Ministry of Economics of Latvia within the project "Establishment of laboratory of material radioactivity and hygiene". Two study directions could be carried out in this Laboratory: evaluation of microbial contamination of various foods, and studies in food microstructure.

The internal projects of LLU supported the improvement of its infrastructure, and the recently installed Laboratory of Bread Technology is one of the examples. In the Department of Food Technology, a "team of bakers" is created – five young researchers have joined their efforts to do extensive research into bread quality and related topics. Financial support from the European Social Fund for engineering is a great support for doctoral students; it offers possibility of attending international conferences as well as of paying for analyses that cannot be done in the Faculty's laboratories.

Development of new food types from the raw materials of plant and animal origin, and their production technologies

The research on the new food processing technologies and new products is still very topical, especially regarding healthy foods and methods of their providing. During the last ten years at the Faculty of Food Technology, several doctoral theses closely connected with issues of food quality and processing have been worked out and defended.

A breakthrough in the last year was confirmation of the project "Formation of the research group in food science", which was implemented within the European Social Fund activity "Involvement of human resources in science". The project was launched in January 2010 and continued until 31 December 2012. Total financing made 1 123 321 LVL. The aim of the project was formation of a multidisciplinary research group for integrated study of food system in order to obtain

innovative, safe and high quality food products. Researchers from the field of food, agriculture, biology and economic sciences joined the group; there were young researchers, PhD students, master students, Masters, and experienced PhD researchers.

The research within the project of the state research program in agrobiotechnology "Innovative technologies for obtaining added value, safe and healthy food products from genetically, physiologically and biologically diverse raw materials of plant and animal origin" have been completed with good results at the end of 2009. The project covers the following activities:

- Evaluation of the qualitative and quantitative properties of physiologically active compounds of *Oryganum vulgare* L. and *Thymus ssp*. L. collected during the research expeditions;
- Study of qualitative and quantitative changes in spaces harvested depending on the clone of the spice and the growing conditions, evaluating the content and composition of volatiles as well as of the antioxidant and microbiological activity;
- Determination of the most suitable flaxseed varieties for oil production, and development of new production technologies for preserving active compounds using natural components from the plants grown in Latvia;
- Improvement of the production technology of bread with increased nutritional value using cereal varieties rich in functionally active substances and grown in Latvia;
- Evaluation of the content of functional components (vitamins, resistant starch, etc.) in potatoes, assessment of the changes in amino acid composition and reducing sugars in potatoes during their thermal treatment, and working out of recommendations for optimum thermal treatment parameters which would preserve the most of functionally active compounds;
- Development of new processing technologies of non-traditional raw materials of animal origin in order to increase the value of these products and extend their shelf-life.

The major research directions and several promotion works associated to bread technology are: possibilities for improvement of wheat bread nutritive values and development of new technologies for added-value production using oat and buckwheat flour, biologically activated grain, fermented whey, as well as studies on baking properties of wholegrain flour made from different cereals.

Biologically activated grain in wheat bread technology has been studied. The idea to add biologically activated rye, hull-less barley and wheat grain to dough, then to examine the quality and biological value of new products, and to determine the optimal storage conditions for bread was developed. The results of the performed research facilitate the projections that biologically activated grain additive to wheat dough can increase the dough quality and the prepared product would have a high biological value and excellent sensory properties, thus being competitive on the present market. Such grain additive allows prolonging the bread storage time. The research was carried out covering the entire food chain: raw material – producer – consumer.

A study of the convective drying of Latvian wild cranberries has been recently started. The research detected the optimal convective drying parameters of wild cranberries. The content of vitamin C has remained maximal in wild cranberries dried at the temperature of +50±1 ºC. This study shows the changes in polyphenol activity in wild cranberries as influence of hot air drying at different temperatures. Even the content of such polyphenols as gallic, caffeic, and epicatechin

acids has decreased. The drying temperature substantially influences the microflora development in cranberries. It is possible to significantly decrease the content of LAB, mould, and fungi in berries if drying temperature of the wild cranberries does not exceed +50±1 ºC, thus prolonging the shelf-life of a ready product.

A study has been performed to obtain a new type of product – Cheddar cheese snacks –, operating with a not-long-ago acquired vacuum microwave dryer. Cheese snacks the same as cheese balls and chips are very popular worldwide. There are many possibilities for cheese snack production, such as drying in freeze dryers and extruding. As it is known, the taste of Cheddar cheese is very distinct, and therefore it is very suitable for producing dried products – cheese snacks. The time for Cheddar cheese drying in a vacuum microwave drier is approximately 23 min. The microwave dryer was used for drying process studies of vegetables (carrots, beets), as well as of beef cut in small strips.

An interesting study was carried out on widening the use of oat products in a diet – a technology for obtaining hydrolyzed oat flakes by enzymes (*Termamyl SC, Fungamyl 800L*, *Amylosubtilins G3x*), and separation of the hydrolisate into two fractions, soluble and insoluble, has been developed. For the first time, a method has been recommended in Latvia for using soluble fraction of hydrolysed oat flakes for preparation of a new product – juice drinks; the rheological qualities of the soluble fraction of hydrolysed oat flakes and juice/ hydrolysed oat flake soluble fraction have been explored. Technology of preparation of wheat bread with undivided into fraction hydrolysed oat flakes and their insoluble fraction addition have been explored, and the influence of their addition on bread quality has been tested.

Ostrich breeding has been recently started in Latvia, therefore processing of ostrich meat has become an urgent issue. The chemical composition of ostrich meat has been analyzed and compared to that of beef and poultry, and physical and chemical parameters of ostrich meat, beef and poultry of various ages have been analysed.

Sourdough is essential in rye bread making, and the tradition of rye sourdough fermentation corresponds to the rye-growing areas in northern, central and eastern European countries, including the Baltic States, where rye bread constitutes a considerable amount of the bread consumption. Traditional sourdough bread production technology is based on a spontaneous fermentation process from lactic acid bacteria (LAB) and yeast, occurring naturally in flour. Classic spontaneous sourdough preparation is a multiple stage process that starts with a mixture of flour and water left for a specific period of time. Preparing of sourdough is one of the oldest biotechnological methods, but the research is still going on and is crucial. In Latvia, the spontaneous sourdough starter is used in traditional dark rye bread baking. Results of scientific experiments show that application of spontaneous sourdough in rye bread production may cause unstable quality of rye bread, though LAB starters selected in Europe frequently do not satisfy Latvian bakers. Therefore it is necessary to investigate the microflora of spontaneous sourdough, and its metabolites. Moreover, selected LAB starter cultures from spontaneous starters should be used in sourdough fermentation to obtain rye bread of high biological value and constant high quality. Studies on rye sourdough are being carried out in the Research Laboratory of Microbiology of the Department of Food Technology of the Latvia University of Agriculture. Technological and biochemical parameters of spontaneous sourdough starters, as well as studies on sourdough microflora and its identification are the major fields of investigations in our laboratories.

Researches to ensure food quality and safety

One of study objects at the Faculty of Food Technology is food safety, which is closely related to the development of the new research field – riskology. Within the scope of the research, a study was carried out on hazard analysis in food and catering industry – microbiological risk factors in public catering were analysed. As a result, risk management models were developed for technological processes of the production of high doneness semi-products and ready-to-eat products. Currently, a study on hazard analysis of technological processes in the catering industry is focused on the processing of game meat (deer and beaver meat).

For the first time in Latvia, a significant study was accomplished to determine and evaluate the quality of organic milk. The quality of organic milk in Latvia has been evaluated in complex; the concentration of antibodies in organic milk was determined for the first time. The potential differences in chemical composition of organic milk have been analysed and studied, taking feeding, namely, data of the composition of forage, and cow blood tests as a basis. Differences in chemical composition and quality of milk obtained from two various agricultural systems in Latvia have been explained. The chemical composition, including the content of calcium, immunoglobulin, lactoferrin, lysocyme, and urea, was investigated, the microbiological quality of organic milk and somatic cell count was evaluated, and the evaluation of chemical contamination of organic milk was carried out. The obtained results verify that separate parameters of milk chemical composition (lactose, fat, IgM, and lactofferin content) and quality are higher in organic milk samples; at the same time, the content of thiamine, riboflavin and IgA is higher in conventional milk. Research results do not allow highlighting or ignoring the quality of milk obtained from one or other agricultural system. The quality of organic milk is evaluated, and this evaluation enables grounded conclusions about the significance of organic milk in the consumers' diet to be made. The properties of prebiotics and their use in production of new functional food products, which allow supplementing dairy assortment with new fermented products, have been studied as well.

Development of sensitive analytical methods for determination of carcinogenic mycotoxin sterigmattocystin in food systems has been accomplished.

During 2008–2011, the associate professors have published nine monographs, and 53 scientific papers in international and local proceedings; scientists have obtained 30 patents for their inventions.

Study of the influence of new-generation packaging materials on the food quality and shelf-life extension

Because of the continuous development, novel information on the new packaging materials and up-to-date technologies, food packaging has become one of the most interesting sectors for research in the food chain. Food technologists are concerned about the influence of new biodegradable materials on food quality during the shelf life. In comparison to conventional packaging materials, there are a few studies available on interaction between biodegradable materials and different food products; therefore this is an area of research interest to a group of the Faculty's young researchers.

The use of environmentally friendly plasticized biodegradable polyhydroxybutirate (PHB) material, as well as the influence of commercially available PLA films has been tested on packaged food quality during the storage time of different foods. Part of the studies deals with the influence of equilibrium modified atmosphere (EMAP) on fruit respiration rate during storage and

accordant fruit and vegetable quality maintenance using special packaging materials envisaged for this purpose. Properties of PLA films comply with requirements to develop EMAP in the fruit and vegetable packages, and the optimum parameters and the shelf-life in this biodegradable packaging have been estimated.

"Sous vide" process can be mentioned as a new packaging technology, industrially not used in Latvia up to now; its main advantage is mild thermal treatment in vacuum packages below 100 °C. A new technology for preparation of marinated ostrich meat and chicken fillets with vegetables using "Sous vide" treatment has been developed, and the optimum technological parameters have been established. The technology has been patented in Latvia as a method for chicken fillet preparation including marinating in fruit and berry sauce, rich in organic acids, and in semi-dry white wine at refrigerated temperature in individual polymer packages – pouches or thermoformed containers, from which substantially all air has been removed prior to final sealing of the containers, then product was placed in a refrigerator for a definite time – 20–24 hours. After marinating of the vacuum-packed product, "Sous vide" technology was applied.

Two inventions in Latvia refer to food industry – ready-to-eat foods. There are disclosed novel processes for considerable extension of the shelf life of pasteurized meat-containing salad with mayonnaise using a novel packaging "Sous vide" technology and having a long shelf life under refrigeration. This process includes essential steps of packaging a meat-containing salad with mayonnaise in individual containers (rigid or flexible), from which substantially all air has been removed prior to final sealing of the containers, followed-up by thermal treatment in a water bath at the temperature of 65±1 °C.

A study has been started on the use of soft packaging containers for retort sterilisation of ready-to-eat foods with meat envisaged for military applications.

Formula of success in scientific work

In the life of the Faculty of Food Technology, having regard of ups and downs in post-war period and later, when there was continuous struggle for the Faculty's existence, these years were only the beginning of maturity, beginning of active scientific research, development and achievements.

In the period of last ten years, attracting European funds, the Department of Food Technology has gained new possibilities of purchasing equipment for scientific research. In May 2005, thanks to the enthusiasm and persistence of the Faculty's dean Daina Kārkliņa, the first **Research Laboratory of Packaging Material Characteristics** was opened at the Faculty of Food Technology. This is the first laboratory at the Latvia University of Agriculture that has been created by ERAF and ESF funds. The first international projects in our University from 2002 to 2005 were two EU projects: EcoPac, QLRT-2001-01823 "Recyclable and Biodegradable Eco-Efficient Packaging Solutions for the Food Packaging", and PackTeck, G1RTC-CT-2002-05068 "Assimilation and Standardisation of Environmentally Friendly Packaging Technologies within the Food Industry" which in Latvia were coordinated by Lija Dukaļska. Main tasks were: to sum up and release information in each country about the effects of the used packaging material on pollution of environment, and to inform society about the development of the latest generation packaging materials and the recycling of old materials into new ones.

We consider this as a gift that allows us to carry out scientific work on such level we only dreamed of before. The Laboratory was planned for modernization of the Food science's doctoral programme. Doctoral programme students and partly also master and bachelor course students are

working on their theses here. In former days, doctoral students had to look for funding, so they could work for several months in other universities of Europe. Currently, most of experiments can be carried out in the new Lab.

The name of the Laboratory is a little bit misleading, because we are researching neither manufacturing of packaging materials, nor its characteristics. One of the research directions about packaging in the branch of food science is to analyse external factor effect on the packed product's quality and changes over storage period. Sector of packaging in the chain of food circulation right now is the most interesting part, because there is continuous development, interesting information about new materials and technologies can be found each day. We as food technologists are interested in the effects of new biodegradable polymers on the quality of food during the storage of these products. Compared with conventional packaging materials, till now there haven't been much research in biodegradable polymer interaction with different food products and effects on food quality. This is a reason why a group of young scientists at the Department of Food Technology are paying attention to these studies. Assistant professor Sandra Muižniece-Brasava has presented her Doctoral thesis "Environment-Friendly Poly-b-hydroxybutyrate Composite Materials for Food Packaging".

The **Research Laboratory of Microbiology** was created with support from the Ministry of Economics in the framework of the project "Creation of Material Radioactivity and Hygiene Laboratory". The Laboratory allows working on scientific research in microbilogical pollution from different types of food products as well as on the structure of food products. In this Laboratory, together with doctoral, master and bachelor programme students, works professor Līga Skudra and her student assist. prof. Dace Kļava. For this and other similar labs, thanks go to the chief manager of the projects – professor Ruta Galoburda.

Research Laboratory of Bread has been created from internal project resources for improvement of infrastructure. Main initiators were associate professors Daiga Kunkulberga and Dace Kļava. At the Department of Food Technology there is a "team of bakers" consisting of five young scientists that are studying various topical issues related to the quality of bread. The main research directions related to bread are: wheat, rye and other grains, and quality of flour obtained from them; rye flour scald characteristics, and dynamics of sugar formation (Evita Straumīte); increase in wheat bread nutritional value, and development of new technologies by adding oat and buckwheat flours (Dace Kļava); biologically activated grains (Tatjana Rakčejeva); different additives such as oat hydrolyzates (Ilze Grāmatiņa) and fermented whey (Elīna Sturmoviča); baking properties of whole grain flour from different species of cereals. This team of bakers actively cooperates with many companies, such as AS "JLM grupa" production unit in Jelgava, SIA "N.Bomja maiznīca „Lielezers"", State Stende Cereals Breeding Institute, State Priekuli Plant Breeding Institute, AS "Rīgas Dzirnavnieks", and AS "Jelgavas Dzirnavnieks".

During the last five years, professors of the Department of Food Technology have gained a lot of experience while being involved in many projects funded by EU. Themes of European projects are mostly related to gathering and summarizing information, but devices that we have purchased will allow us to be involved in more important research projects on food quality, safety and period of food storage.

The coordinator in Latvia for the other two projects, mentioned here, is the head of the Department of Food Technology – professor Daina Kārkliņa. One of the projects is SAFEFOODNET FOOD-CT-2004-513988 "Chemical Food Safety Network for the Enlarging

Europe", which was carried out in years 2005 and 2006. The aim of this project was to monitor the chemical pollution of food, and the role of controlling organizations in discovering this pollution. The other project, which involved universities related to food science from almost every EU country, was 104934-CP-2-2003-1-PT-ERASMUS-TN "Integrating Safety and Environmental Knowledge into Food Studies towards European Sustainable Development". The main aim of this project was to try to unify programmes and create connections. The European Commission is systematically extending this project, and it is still active. The international project, which involves all northern countries including Latvia, at the national level is managed by the dean of the Faculty of Food Technology – professor Inga Ciproviča. The aim for this project is to collect scientific knowledge and research results about the changes in fat, protein and lactose in the process of cheese ripening. Different courses, workshops, and conferences are organized. Also there is exchange of experience as well as acquisition of new experiences while working in the laboratories of other scientific institutions. One of the latest international projects is EUREKA "Fermented Products by Using Lactic Acid Bacteria with Antimicrobial Activity for Bread Production", the project manager is associate professor Daiga Kunkulberga.

International cooperation in food science research

In the last five, six years, the technological stuff of the Faculty of Food Technology has gained significant experience whilst accomplishing several European-funded projects side by side with researchers from various institutions of European countries. The topics of the already completed European projects were mainly associated with collecting and analysis of information, but today a new horizon opens up thanks to the well-equipped laboratories where experimental research on food quality and safety can be carried out at world level.

The main tasks of the projects were dissemination of information within participating countries on the problems related to influence of used packaging on the environmental pollution, educating of consumers about packaging materials of the new generation and their introduction into market, as well instruction in the existing recycling technologies of used packaging.

The international project involving all Nordic and Baltic countries at the national level is the project with the aim to generalize the knowledge and research results on the changes in fat, protein and carbohydrates in processes occurring in cheese maturation. Within the mentioned project, various workshops for PhD students, conferences and symposiums have been organized for exchange of experiences, as well as training in the partner institutions have taken place. One of the latest projects being in the progress at the time being can be mentioned international EUREKA project "Application of Antimicrobial Lactic Acid Sourdough in Bread Production".

Quality is important in Latvia if our goal is integration into European and global food system. For this reason, it is necessary to turn from production of raw materials towards their processing into products of high quality in appropriate packaging suitable for retailing purposes.

The quality criteria of food products are in continuous movement and development. It is determined by the saturation of food market, demographic changes, and the change in consumers' attitude towards food products and quality criteria. The available information and results on food market and consumers serve as the main drive for the further improvement of food product quality criteria and the development of new food products.

Technologies play an important role in the transition period; the main direction of their development is preservation and optimization of the most important substances present in food.

Minimum processing principles could be applicable, for example, introducing non-thermal processing technologies. New technologies should suit market requirements; they should be profitable, competitive, and relevant to international development tendencies in this direction, open to further development and improvement. Four basic conditions are necessary for the implementation of a new technological process: clear strategy, business process, resources, and organization.

The improvement of food product quality and the development of its criteria should be based on research findings which are realized on the basis of a typical scientific scheme, ERTDI (E – education, R – research, TD – technologies, I – implementation), and performing research in improving one specific quality criterion, e.g., its impact on health. A lot of experiments should be carried out in the course of the process, analyzing the characteristics of a newly created product, the level of harmlessness, ecological aspect of the technological process, possible market before launching the product. For example, for the development and implementation of the product "Auzu biolakto", approximately four years were required.

Therefore a brand new innovative methodology is required to shorten and make more effective the way from the new idea in research to a ready-made product that is offered to consumers in the market. The classical route might be avoided only by means of subsidies, venture capital and developing special instruments such as business incubators, research/technology parks and introducing innovative methods in the process, the idea of which is the development of new products and their realization in the market. A move should be done from the classical variant, when innovation is implemented by the company itself, to the new method, when a company implements new ideas and serves as cooperation facilitator between innovators, universities, business incubators, science/technological parks, etc., and is the driving force in generating ideas and doing research.

Conclusions

1. The first most significant researches at the Faculty of Food Technology are related to introducing non-residue technologies in milk processing factories, wood acetylation methods, heating processes and energy consumption in agriculture and food processing technologies, development of new kind of fuel and its use in agriculture, alternative methods of heat production.
2. For the future development of the research work at the end of the 20th century, it was proposed that the research strategy should move to more fundamental researches, the result of which could be used more extensively in the development of more new products within the food companies.
3. Recently (since 2000), the technological equipment has been greatly improved thanks to the support of European funds. A new Laboratory of Analysis of Packaging Materials with modern equipment was opened using the ERAF funding.
4. During the last decade, a new generation of young talented researchers have engaged into research work at the Faculty of Food Technology.
5. The European Social Fund grants, the purchased modern equipment and measuring devices, creative cooperation between PhD students and their supervisors, as well as international research projects promote and favour the research activities taking place at the Faculty of Food Technology, and are a prerogative for further successful achievements in the local and international research space.

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Development of Materials and Structures for Rural Engineering

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Abstract. The main research area in structural engineering deals with materials in all aspects, starting with raw materials, the analysis and developing of composite building materials, and ending with reliability and optimisation of engineering structures. The developing and investigation of materials and structures with needed properties has become one of the most important sectors in this research area. Reliability of structures – the new research field – was developed depending on the use of different new materials and taking into account environmental effects, especially in agricultural buildings. During the last decade, due to support from European funds and financial resources from the Latvian Academy of Science, theoretical investigations have been performed and modern equipment has been obtained. In the future, the development of the scientific research activities and results will depend on material resources and international scientific activities of researchers.
Key words: Building materials, modification, optimisation, reliability and durability.

Introduction

The basic task of the structural engineering branch at the Faculty of Rural Engineering is educating of teachers, researchers and engineers for the building industry. During the last decades, active scientific work characterizes the structural engineering branch at the Faculty of Rural Engineering in respect of the teaching staff as well as of postgraduate, master and bachelor students. Research activities are the basis for new research facilities, for improvement of education quality, and long-term cooperation with international partners. Research in structural engineering is mainly related to the following issues:

- developing and investigation of new composite materials and structures for rural buildings;
- optimisation of wooden, concrete, steel and composite structures;
- reliability and durability analysis of structures;
- investigation of environmental effects on different kinds of materials.

Behaviour of materials, and optimisation and strengthening of structures

Effect of material properties on behaviour of structures. A problem of great concern is heterogeneity of construction materials. It is really an urgent problem in structural engineering to choose the behaviour model adequately for design in elastic stage, moreover, in elastoplastic stage, as well as in failure phase. One of reasons for complications is dislocation (or irregularity) as a crystallographic defect within a crystal structure of material for steel structures. The presence of dislocations strongly influences the failure mode of material. Some investigation of irregular crystallic models has been carried out resulting for prognosis of unfavourable compression and tension strength ratio possibly generated before failure (Паберзис, 1984). The effect of material structure and behaviour in loading process has to be taken into account in design of real engineering structures.

Optimisation of structures. Optimization of bearing structures play an important role in design, the very purpose of which is to derive a maximum benefit from the available resources, which means

the minimization of material consumption leading normally to minimal costs. In addition, in design of structures, the strength and serviceability limit states have to be fulfilled. During the last decades, there have been developed some numerical techniques for modelling algorithms for geometrical non-linear structures: 1) increasing of algorithms effectiveness; 2) geometrical non-linear frames; 3) geometrical non-linear trusses. The methods and algorithms are developed by B. Kirulis and published on www.b-kirulis.eu.

Reinforced concrete structures. Because of economic activity, the processing of waste quantity and pollution of the environment is increasing. A very important up-to-date problem is collection, storing, keeping and utilization of aggressive sewage and liquid manure. In the case of wet technology in the process of removing manure in farmhouses, the water content of manure can reach from 95 up to 97%. In order to protect the environment, safe keeping of those liquids is possible by using large containers near to the farmhouses and agricultural factories.

The economic solution of containers is reinforced concrete (RC) cylindrical reservoirs. However, they have several disadvantages. In the case of prefabricated reservoirs, very often a leak between elements takes place. Special systems for early detection from small leaks, especially in underground storage tanks, should be developed. Under action of tension, flexure, temperature gradient as well as concrete shrinkage, cracks can form in the vertical and horizontal direction of reservoir wall. That causes a need of expensive repair techniques for treatment of cracks. In order to assure the impenetrability and durability of the wall, it is necessary to check for the material strength and crack formation.

The stress analysis and optimum design of the wall of open aboveground monolithic cylindrical reservoir have been performed, and optimum parameters of reservoir wall taking into account strength and serviceability limit state requirements and discrete material properties have been determined (Brauns and Andersons, 2000, 2002).

In new constructions and especially in renovation of structures, fibre reinforced plastic (FRP) strips are increasingly used as strengthening material of reinforced concrete elements. Immunity to corrosion, low weight resulting in easier application in confined space, elimination of the need for scaffolding, reducing in labour costs, as well as high tensile strength and large deformation capacity are the main positive characteristics of FRP. The addition of externally bonded reinforcement to prefabricated RC beams may be applied to increase structural safety and decrease the risk aspects. The behaviour of RC beams with flexural strengthening has been studied. The effect of external FRP reinforcement on failure mode and stress distribution is determined (Brauns *et al*., 2003).

Basing on the test results and numerical analysis of RC beams with external flexural FRP reinforcement, the following conclusions are drawn:

- application of external flexural reinforcement on structurally balanced beams alters its failure mode;
- unstrengthened beams failed by a collapse of concrete in compressed zone. Beams with external flexural strengthening failed by collapse of concrete in tension at the end of FRP ribbon and following diagonal shear crack;
- the increase in ultimate bending moment for externally strengthened beams is about 7–10%, but decrease in maximum deflection – 17–30%.

Optimal rectangular cross section for RC beams in bending is analysed for determination of lower costs of material (steel and concrete) consumption. It has been found that under optimisation conditions, about 10% of the cash resources can be saved (Paberzis, 1987).

Experimental study has been carried out in field conditions with a large-scale reinforced concrete slabs with variable stiffness. Stress on the contact surface with sand base, reinforcement strain and deformation of the slabs have been measured. Calculation method is also developed, considering non-linear deformation of the slab and sand base, as well as the method for predicting of interaction under repeated loads is offered (Kreilis, 1991).

Large-scale reservoirs are used as a treatment facility for storing of sewage, liquid manure, etc. The design problems of floor slabs resting on ground foundation with low load-carrying capacity have been discussed. Based on the results of numerical analysis, it has been determined that tensile stress (effect of shallow shell) considerably increases the necessary amount of reinforcement (Kreilis and Brauns, 2003).

Technology of permanent stay-in-place forms has many advantages – a ready-made formworks, polystyrene insulation, construction speed, etc. It is necessary to estimate thermal conductivity and load bearing capacity for use in Latvia conditions. The analysis shows that the technology is applied in buildings of up to three stories with insulation thickness of at least 100 mm (Vulans *et al*., 2006).

Steel structures. The resistance of cold-formed sections in compression and bending has been analysed taking into account geometrical proportions, influence of rounded corners and stiffeners. By numerical analysis, effective U- and C-section properties in axial compression and bending in the range of width to thickness ratios (b/t) have been estimated. The range of b/t ratios for calculations and influence of rounded corners and edge stiffeners has been taken into account according to EN 1993-1-3, Section 5. In addition to numerical analysis, results of experimental research with natural beams in bending have been assessed and presented (Dandens *et al*., 2011).

Composite structures. In many cases, very effective is the use of concrete steel composite structures. According to standard LVS EN 1994-1-1:2009 L implemented in Latvia, the plastic resistance of a concrete-filled column is given as a sum of the components and taking into account the effect of confinement in the case of circular sections. In investigations performed, the stress state in composite column has been determined by taking into account the non-linear relationship of modulus of elasticity and Poisson's ratio on the stress level in the concrete core. It is determined that the effect of confinement occurs at a high stress level when structural steel acts in tension and concrete in lateral compression. The stress state and load bearing capacity of a section in bending is determined by taking into account non-linear dependence on the position of neutral axis. Because the ultimate limit state of material is not attained for all parts simultaneously, to improve the stress state of a composite element and to prevent the possibility of a failure the appropriate strength of concrete and steel should be used. The safety of high-stressed composite structures can be improved by using ultra-high-performance concrete (UHPC).

Taking into account the design strength of steel and concrete as well as limit ratios of the circular hollow sections, the analysis of load bearing capacity of the composite column has been performed (Brauns and Kreilis, 1998). It was found that the load limiting factors are concrete design strength and diameter thickness ratio. Using concrete with strength class C35/45 and steel with grade Fe235, the load bearing capacity of the composite column increased by 20% in comparison with concrete of class C30/37. For a thin wall hollow section, instead of a thick wall the steel economy can be 50% (Brauns and Rocens, 2004b).

The optimisation of working conditions and cross section area of a composite structure as well as the prevention of a failure in the case of small thickness of structural steel and fire can be realized by using appropriate strength of concrete and steel as well as composition of materials.

Methods for reliability and durability estimation of RC and steel concrete composite elements have been developed (Brauns *et al*., 2009; Brauns and Rocens, 2010; Skadiņš and Brauns, 2011). It was determined that by using UHPC and concrete reinforced with short fibres as structural steel tube filling, the increase in load carrying capacity can be significant.

The stability of steel-face sandwich panels under bending and axial loading has been studied, and the effect of core material stiffness has been determined (Brauns *et al*., 2005). In the case of light core material, the buckling load of sandwich panels increases linearly with core shear modulus. By increasing the core material stiffness, the effect of shear modulus on critical load decreases. However, the increase in core layer thickness leads to higher buckling load and better thermal isolation as well.

The results of experiments in bending carried out on the specimens cut from panels and full panels by loading equipment Zwick/Roell using software TestXpertII allow determining the mechanical properties needed for prediction of load-bearing capacity and rigidity. Subsequently, the curves of maximum loads and spans have been drawn for various panels (Kreilis and Kikulis, 2009).

Investigation and optimisation of laminated and short-fibre materials

Modification of wood in wooden composites. Hot pressing is one of the important stages during the production of wood-based composites when mats of resinated wood fibres, particles, flakes or veneers are consolidated under heat and pressure to create close contact and form bonds between the wood constituents. Mat deformation is, however, not uniform across the material thickness resulting in a density profile in pressed composite boards. This in turn has significant effects on the physical and mechanical properties of the final product. The initial mat structure and the mechanical properties of its components govern the overall mat stress–strain relationship. Due to the viscoelasticity of wood, some elements exhibit time-dependent creep behaviour and may undergo stress relaxation.

As resin in wooden composites is employed in limited amount, bond efficiency relies on the degree of mat densification, which should be high. Increasing mat density, however, causes detrimental effects such as increased weight and wood consumption, and excessive thickness swelling in service when the product is subjected to high humidity conditions.

Mechanically modified wood by compression, to flatten its cavities, and by cavity filling with other materials improves wood strength and stiffness. The mechanical and hygromechanical quality of wood composite boards depends on the properties of layers and on the alignment of these (Brauns and Rocens, 2007a).

Structural changes in technological pressing of wooden composites. Studies on wooden composites have focused on the relationships between processing parameters and material properties caused by densification. In manufacturing of a composite board, the basic function of the pressing operation is the development of an adhesive bond between individual flakes or veneer sheets while minimal glue spread is utilized (Brauns, Rocens, 2007b).

The structure of a mat made of fibres exhibits a double cellularity. Void space among the strands results from the inherent randomness of the deposition process, and the flakes include the cell lumen. It is thus possible to distinguish not only two different voids, but also two different densities: density of the mat, and average density of the fibres. During the first stage of pressing, voids' space between flakes is eliminated from the mat structure and the flakes get into contact. Further pressurization enhances the collapse of cell walls and the lumen volume is decreased. The volume of the mat is the sum of the volume of the flakes and of the void space. At this stage, both the density of the mat and that of constituent flakes increase.

Viscoelastic behaviour of wooden composites. Viscoelasticity influences wood modification when wood flakes or veneers are under static pressure and subjected to changes in temperature and moisture content. In these situations, wood can be adequately treated as a linear viscoelastic material.

The high pressure applied during the manufacture of wood composites, coupled with the random mat structure, results in a non-linear and non-uniform mechanical response of the wood constituents. Time-dependent stress–strain relationships, instantaneous and delayed strain recovery, permanent deformation, and temperature and moisture-dependent stress relaxation may intervene during the pressing process (Brauns and Rocens, 2007a).

Influence of composite structure on hygromechanical behaviour. The distribution and properties of densified flakes determine the load carrying capacity of the board. Oriented strand boards can increase the strength and the stiffness of wooden composites. Nevertheless, the warping of panels is very high. As a result, the quality of wood composite boards depends on the properties and alignment of flakes.

In general, wooden composites do not display symmetry with respect to the midplane; their properties can be either asymmetric or antisymmetric. The composite has been analyzed as a system of parallel elementary layers. The local co-ordinate system has been associated with the principal directions of the elementary layers. In order to approximate the stress state, stress-gradient-dependent force-stresses and couple-stresses are used in the model.

The multilayer model and model based on the laminate analogy was used to determine the behavior of layered and fibre composites. Non-symmetric moisture distribution causes linear expansion and hygromechanical warping. Curvatures resulting from hygrodeformation of wood were computed using the method developed in the research of Brauns and Rocens (2004a, 2011).

The midplane strains and curvatures of wooden composites depend on the content and distribution of moisture. The hygroscopic deformation model contains seven veneers with equal thickness of 1.4 mm. The partial density of plywood (birch) is 660 kg m^{-3}. The results, which compare the properties of densified and of customary wood, showed the effect on curvature of an asymmetric non-linear distribution of moisture and antisymmetric structure at a uniform moisture content.

Short-fibre materials, and estimation of fibre length effect. Short fibres can offer advantages of economy and ease of processing (Brauns, Rocens, 1998; Brauns, Andersons, 1998). However, when the fibres are not long enough, the equal strain condition no longer holds under axial loading, since the stress in the fibres tends to fall off towards their ends. This lower stress in the fibre, and correspondingly higher average stress in the matrix compared with the long fibre, depresses both the stiffness and strength of the composite. It is therefore necessary to quantify the change in stress distribution as the fibres are shortened.

Several models, ranging from fairly simple analytical methods to complex numerical packages, are commonly available. The simplest is the so-called shear lag model, which is based on the assumption that all the load transfer from matrix to fibre occurs via shear stresses acting on the interface between the two constituents. Wide investigations of steel fibre pullout and modeling of bridging effects in steel fibre concrete have been performed (Skadiņš and Brauns, 2010, 2012).

The methods developed allow examining the predicted stiffness as a function of fibre aspect ratio, fibre/matrix stiffness ratio, fibre volume fraction, and other effects on the distribution stresses, as well as allow predicting whether fibres of the specified aspect ratio can be loaded up enough to cause them to fracture. The model developed gives possibility of evaluating the bending stiffness

for a given cross-section in the cracked and uncracked range, determined on the basis of moment–curvature relationship. Moment–stiffness relationships are useful in design of flexural SFRC elements with random orientation of short fibres.

Determination of elastic characteristics and strength of materials. The mechanistic approach is adaptable to the computation of composite material properties that characterize the material averaged responses, such as the prediction of composite compliances from micro-mechanical analysis. For a general composite laminate loaded in an arbitrary direction, a systematic approach is needed in order to predict the stiffness and the stress distribution. Simple cross ply and angle-ply laminates are not balanced for a general loading angle. If the plies vary in thickness, or in the volume fractions or type of reinforcing fibres, then even symmetric laminate is prone to tensile-shear distortions (Brauns and Rocens, 2008b). Computation is necessary to determine the lay-up sequence required to construct a balanced laminate. The fibre aspect ratio, fibre to matrix stiffness ratio, and fibre volume fraction affects the stress distribution as well as the elastic properties of short-fibred material. The fabric function of spatially reinforced composite can be fixed experimentally and used for the determination of elastic properties. By using the properties of unidirectionally reinforced structural elements, the orientational averaging allows determining the lower and the upper bond of elastic characteristics (Brauns and Rocens, 2006).

On the basis of the strength analysis, the form of material failure can be predicted. A phenomenological failure criterion provides feedback for material improvement via structural changes and supplies quantitative strength characteristics of material that reveals pivotal to rational engineering design.

The method developed permits determining the stresses in a thin laminated structure by means of an experimental deflection function. It was established that the fracture occurs at maximum couple-stresses. For some laminates, the delaminating takes place under action of interlayer shear stresses. The failure criterion permits predicting the sites of a fracture and possible load-carrying capacity of a shell upon loss of the stability. For strength-related properties, a failure criterion can provide feedback for material improvement via structural changes.

Investigation of materials with adaptive properties. Laminates can be designed to provide the desired strength and stiffness characteristics required for specific applications. The bend-twist coupling results in twisting of a structure, when a pure bending is applied but stretching twisting coupling can occur when a tensile load is applied. This behaviour is influenced both by the material characteristics of the laminate and geometric properties of the structure to which it is assigned.

The use of fibre-reinforced composite wind rotor blades enables a number of possible passive aerodynamic control options. The investigation of coupled deformation effects of laminated composite materials to obtain the necessary twist and strength of material is an important up-today problem. However, considering the membrane-bending stiffness coupling effects, not only the complexity of the design process increases, but also the risk of introducing effects that are difficult for designers to detect and account for (Brauns and Rocens, 2011).

The rotor blades are usually made using fibreglass mats impregnated with polyester or epoxy. The blades may be made wholly or partially from carbon fibre, which is a lighter but costlier material with high strength. Wood–epoxy laminates are also being used for large rotor blades. Experimental results indicate that wood is both a viable and advantageous material for use in wind turbine blades. This material is reasonably priced, domestically available, ecologically sound, and easily fabricated with low energy consumption.

Anisotropic properties of fibre-reinforced materials provide that the blade twists into stronger winds to reduce transient loading. By using adaptive blades with twist coupling there is a possibility of keeping good, steady power-production and smooth out unwanted peaks in loading. On the basis of investigations it has been determined that in the case of in-plane balanced laminate, anti-symmetric orientation of skin layers can be used to ensure the necessary adaptive warping and strength of the laminate under action of radial force in the rotor blade (Brauns and Rocens, 2008b).

Variability of properties and reliability of timber structures

Variability of properties of structural timber elements. During the 1980s, investigations related to timber structures were carried out in cooperation with Estonian colleagues emphasizing the structural response to variation of wood properties (Кесккюла and Озола, 1984). In order to prove and compile the available information on properties of structural softwood timber, the variation of wood strength and stiffness data has been analysed. It is concluded that more valid information about clear wood strength may be obtained from test samples containing 70 specimens and more. Analysis of the representative strength data samples provided of an equal chance of being selected proved that the sample mean values are located near the population mean and may be assumed as a more stable statistical indicator for predictions. Analysis of correlation between wood strength and density proved that for high density ranges (above 500 kg m^{-3}) the proposed regression models are not valid (Ozola, 2004, 2005).

The sensitivity of structural timber elements to an uncertainty of different combinations of affecting factors has been studied (Keskküla and Ozola, 2001). The probabilistic calculations of bearing capacity of timber elements based on the tested variables proved that the considerable decrease in reliability is expected for elements subjected to both longitudinal and lateral buckling the capacity of which to resist external forces is affected by much more factors than the ones loaded in bending (Keskküla and Ozola, 2003). A serious study has been carried out on the properties influencing the behaviour of bearing structures with purpose to point out the structural elements tended to overstresses, and to take precautions to ensure a larger safety (Ozola *et al*., 2007; Ozola, 2009).

The latest research work in timber area is devoted to experimental investigation and modelling of creep beahaviour of beams under variable environmental conditions (Ozola and Brokans, 2012).

Consideration on design models. The phenomenological approach is maintained in structural analysis of timber structures, testing all really possible design models with purpose to reveal the extremal values of internal forces possibly generated. For the choice between different structural solutions it is proposed to implement the limit state toughness and the amount of mechanical energy to be stored by the structure as determining indices (Ozola, 2010). The bearing capacity of more stressed sections have been examined simulating heavy loaded glue laminated timber elements by a lattice frame model in order to obtain more information about variation of internal forces due to distinctive stiffness zones in a beam. In addition to conventional design procedure, the importance of application of orthotropic model for stress state analysis of glulam elements has been proved in order to obtain the values of the design stresses more closely to the real ones (Ozola, 2008).

Uncertainties involved in structural timber design by different code formats. In the 1990s, when two building codes, the Eurocode 5 and LBN-206-99, represented legally acceptable instruments for design of timber structures, a study of a new methodology as well as a discussion

on distinctive design results normally followed. An aspect using Eurocode design conditions is increasing the efficiency of the structures due to more precise methods used for stress analysis and capacity evaluation. Latvian code LBN 206-99 for design of timber structures provides the design methods more simplified including wider safety margins. There is a possibility of increasing the efficiency of timber structures using the Eurocode 5 approach in design, thus avoiding the excessive safety margins. For this reason, it is necessary to take into account that the reducing of the design safety margins leads to the need to provide appropriate supervision and quality control measures during the erection and maintenance of the structures (Keskkula and Ozola 2002; Ozola and Keskküla, 2005).

Conclusions

The investigations in the civil engineering science are based both on theory and on experimental research work. The development tendencies in the civil engineering science are linked with the applied engineering problems and development tendencies of Latvia. The major areas of research activities in the future are:

- elaboration and investigation of building materials incorporated by particular properties of considerable industrial interest and competitiveness, the use of the local and recyclable raw materials in production;
- economy of energy and environmental resources;
- integrated development of strategy and technology of construction production with the progressing activities in the European Union.

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Investigations of Materials and Technologies for Rural Buildings

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Annotation
Technologies of agricultural production, processing and storage, as well as livestock breeding technologies are tightly linked with construction – selection of appropriate building materials, structural solutions, and indoor climate control. By improving these technologies, the requirements set for buildings and their structures become increasingly strict. The article deals with scientific researches carried out by the teaching staff of the Department of Architecture and Civil Engineering and of the Department of Structural Engineering – mainly on livestock sheltering, agricultural products storage buildings, building materials and construction products for rural buildings, and the specific requirements for their installation. Researches include also possibilities of developing foam gypsum construction materials as well as heat, sound insulation and finishing products made from composite plant-fiber filled materials on the basis of foam gypsum. In the field of construction economics, research has been performed on the marketing problems of Latvian-produced construction products, particularly ceramics. The paper deals also with research on indoor climate, mainly on its improvement in livestock buildings, heat recovery possibilities of ventilation systems, heat loss reduction potential in buildings, as well as on use of solar and geothermal energy for heating of buildings.
Key words: Rural buildings, building materials, foam gypsum, microclimate, optimisation.

Introduction

Scientific research activities at the Building Department have been undertaken already since its establishment – in the 1950s, when a necessity arose to deliver study courses in structural engineering for students of the Faculty of Land Reclamation and Land Survey (HMF), and in building and construction for students of the Faculty of Agriculture and the Faculty of Agriculture Mechanization.

Since 1975, when enrollment of students was opened at the study program "Civil Engineering" of HMF, scientific activities at the Department expanded. Due to increase in the number of students and in order to improve the quality of study work, teaching staff of the structural engineering and structural analysis study courses was separated from the Building Department, and the Department of Engineering Structures was formed; later, in 1993, it was renamed the Department of Structural Engineering. When the study program "Landscape Architecture" was opened in 1997, the Building Department was renamed the Department of Architecture and Civil Engineering. Although the study training work at both the Departments is specialized, they cooperate in research and development, as well as involve researchers from other faculties and institutes – most often from the Technical Faculty and the Faculty of Information Technology (the Department of Physics).

During the last twenty years, research cooperation with foreign universities and research institutions has been going on. In 1995, enrollment in the Master's degree study program in civil engineering was launched as well as doctoral research work was encouraged. Thanks to the EU co-financing over the past 10 years, several new research and study laboratories with modern equipment have been established.

Research activities at the Departments are performed in the following areas:

- investigation of traditional and new materials and their applications, mainly in livestock containment buildings (floors, walls);
- development of new foam gypsum modifications, examination of foam gypsum performance properties and its application as thermal insulation, acoustic and finishing construction products (investigations have been led by prof. J. Skujans at the Department of Architecture and Civil Engineering already for 25 years);
- livestock farming technology, layout, design, structures and construction of cattle sheds and barns, mechanization of livestock breeding facilities (researches carried out by assist. prof. J. Augstkalniņš, and in later years – by assoc. prof. S. Štrausa);
- indoor climate in animal facilities, and opportunities to improve it;
- energy efficiency and energy saving possibilities in buildings, including energy efficiency of the space ventilation systems;
- recently – ecological (green) construction (including utilization of solar and geothermal energy).

Research activities of the staff of both Departments are discussed also in the article: Brauns J. *et al*. "Development of Materials and Structures for Rural Engineering".

Investigations in the area of building materials and their production methods

Scientific activities expanded in 1952 thanks to prof. A. Tramdahs (previously professor at the Latvia University) who was elected the head of the Building Department. Great attention to research in the field of building materials was paid at the Building Department in the 1950s–1960s. During the first post-war decades, the main focus was paid to the studies of cheap and from local raw materials produced building materials suitable for construction of rural buildings. Studies on the constructive solutions and structures of agricultural buildings have been topical since establishment of the Building Department.

Properties of concrete (especially its durability) were investigated by L. Blūma under the scientific leadership of prof. A. Tramdahs. Results of the theoretical and laboratory investigations were verified in field testings. L. Blūma's research resulted in defence of her doctoral thesis "Experimental studies of elastic properties of concrete after cyclic freezing" (Блума, 1956) and in the research paper on flexibility of refrozen concrete (Blūma, 1959). Afterwards her research interest was durability and mechanical properties of concrete in the process of its ageing (Blūma, 1960).

Much attention has been paid to research on local building materials – properties of most widespread timber species of trees, as well as possibilities of utilization of wood by-products and processed agricultural products for production of cheap local building materials. J. Šutka examined properties of ash wood and dependence of timber properties on the tree growing conditions. The results of his research were summarized in his dissertation (Шутка, 1958a). J. Šutka's research was performed in cooperation with the Institute of Forestry Problems and Wood Chemistry and the Institute of Construction and Architecture of the Latvia Academy of Science (Шутка, 1958b; Šutka, 1958, 1959). In subsequent years, J. Šutka searched for possibilities of utilizing the low-value timber

in rural construction. Cooperation was successfully accomplished, and in the year 1962, the State Construction Committee approved the Guidelines for production of finewood blocks and their use in construction.

In later years, from 1960 to 1980, scientific efforts of the teaching staff, postgraduate students and research students of the Building Department and the Department of Engineering Construction involved investigations of new and efficient building materials and construction products, particularly for Zemgale region. Research student V. Leimanis, managing engineer of the Jelgava Building Materials plant, studied and introduced a new production technology of wood wool slabs and three-layer concrete–woodwool wall blocks. His research output was a new three-layer panel composition for agricultural and industrial buildings (Астапенок *et al*., 1974).

In the 1980s, J. Skujāns began research on foam gypsum compositions, performance, and possible use as a finishing material in buildings. While studying in postgraduate courses at the Riga Polytechnical Institute, J. Skujāns examined the effect of surfactants on the rheological properties of gypsum paste, as well as the influence of a variety of technical factors on technology of the foam mixes. The foam gypsum of volume density less than 180 kg m^{-3} and thermal conductivity coefficient 0.07 W/m^{o}K was obtained. As a result, J. Skujāns earned his Doctoral degree for "Research on manufacturing methods of the foam gypsum by foaming on sieves" (Скуянс, 1987). Now he is carrying out research on the production methods of foam gypsum with fibre reinforcement filling for obtaining of thermal insulation and acoustic materials.

Assistant prof. I. Geidāns conducted extensive research studies on the properties of both carbamide-formaldehyde foam and lightweight concrete, their optimization, as well as on the options of incorporating these materials in buildings. It was found that for Latvian climatic conditions, three-layer and multi-layer panels with a reinforced bearing layer and a *preserved* insulation layer are more favorable for installation in envelope structures of residential buildings and cowsheds instead of monolayer expanded clay concrete wall panels (Гейданс *et al*., 1982; Карвелис *et al*., 1983; Зариня *et al*., 1987).

Assoc. prof. A. Šteinerts and the head of the Building laboratory J. Students conducted research studies on optimization of production of wood wool slabs and aerated concrete units. Laboratory and industrial investigations were carried out with the aim to optimize technology of the production of an aerated concrete to reduce the power consumption and the time of heat treatment cycle. It was found that for autoclave curing of an aerated massive with a thickness of over 30 cm, it is more advantageous to have heat treatment cycle with the so-called *purging* (pre-air release of the autoclave by steam). A. Šteinerts established that duration of *purging* is proportional to the mass and thickness of fresh concrete details subjected to the steam curing, and inversely proportional to the steam consumption. The results of his investigations were introduced at the Reinforced Concrete Structures Plant No. 1 in Vangazi. On the basis of A. Šteinerts' research, the shortest heat treatment (autoclave)-cycle of large aerated concrete building components, used already in the former USSR, was designed (Штейнерт, 1983).

In the first half of the 1990s, during the transition period of the national economy under conditions of the economic crisis, the issue of development of cheap local building materials based on local raw materials became topical. There were studied opportunities of developing lightweight compositions for masonry units on the basis of gypsum binders and by-products, and waste base products of agricultural production. A. Šteinerts found out that lightweight concrete compositions on the gypsum–cement binder and flax shaves or sawdust can be produced with a density from 550 to

1500 kg m^{-3} and compressive strength from 4 to 20 MPa. G. Andersons, B. Kirulis, and J. Jurševskis conducted technological research studies in the co-operative society "Kalnciems", which resulted in production of lightweight sawdust concrete units (Steinerts, Andersons, 1996).

In the recent 15 years, scientific activities of the teaching staff and research students of the Departments of Architecture and Civil Engineering and of Structural Engineering have been focused mainly on the optimization of foam gypsum modifications and on the economical problems of production of construction products, including evaluation of the standardization process and conformity assessment procedures in construction industry.

Development of new thermal isolation and acoustic materials and their production technologies

The foam gypsum production technology and the acquired material (volume density – 200–700 kg m^{-3}) quality investigation is the main research field. The objective of the research is to develop a construction material to be used for heat and sound isolation. Along with this, research has been initiated to develop a foam gypsum mixture by using various organic fillers. Prof. J. Skujāns is leading a research team to develop modifications of plant-fibre reinforced foam gypsum, as well as finishing materials for both thermal insulation and acoustic construction products. This research group is currently involved in execution of the project co-financed by the European Regional Development Fund (ERAF) "Development of new composite materials on foam gypsum basis with fibrous reinforcement and their systems". In the project's working group, researchers and doctoral students from several faculties of the Latvia University of Agriculture (LLU) are involved.

Prof. A. Adamovičs and other researchers from the Faculty of Agriculture do experiments to find out which hemp variety is suitable for growing in Latvia for use in the manufacture of foam gypsum composite materials. Prof. A. Kaķītis and researcher U. Bērziņš (Faculty of Engineering) carry out researches on the equipment for granulation of fiber plants. Assoc. professors A. Šteinerts and G. Andersons and doctoral students R. Brencis and I. Preikšs from the Faculty of Rural Engineering develop research on production of foam gypsum composite construction materials by adding hemp shives. Prof. U. Iļjins and researchers U. Gross and A. Gajevskis from the Faculty of Information Technologies study drying and heat transfer processes.

Nowadays, the world technical progress in construction of buildings is aimed at the use of materials with such properties that each layer in multilayer constructions carries out the functions it is assigned to. Foam gypsum is a perspective material in construction. Gypsum binders are widely used in the manufacture of gypsum paperboard and sound and heat isolation materials for the building of monolithic one- and two-storey houses. For example, strength indicators in dried gypsum are several times higher than in wet gypsum. According to the requirements of foam gypsum manufacturing, the initial moisture content should be very high. Drying of foam gypsum is an obligatory requirement to obtain a material with appropriate mechanical and heat conductivity properties. U. Iljins and other researchers have made experiments where drying of foam gypsum can be researched by electrical methods that do not destroy the material during the experimental process (Iljins *et al*., 2009). Their study provides the experimental measurements of electrical properties – resistance and capacitance during the drying process. The results show that electrical measurements are a useful tool to characterize the moisture content in foam gypsum. The optimal frequency of electrical measurements at the kilo- and megahertz range has been determined.

A mathematical model of moisture drying adequately describing the experimental researches has been created, and dependence of the main drying parameters of foam gypsum samples on the foam gypsum volume density has been established. These studies were carried out by R. Brencis, U. Gross and other colleagues under management of prof. U. Uljins (Iljins *et al*., 2012).

A new wall structure and its manufacturing technique have been developed by J. Skujāns and other researchers (Skujans *et al*., 2007; Iljins *et al*., 2005a). An experimental wall fragment has been manufactured which consists of the following layers: internal finishing layer (gypsum boards and vapour insulation), foam gypsum, thermal insulation (polystyrene), and a plaster outer layer. The construction element's heat transfer coefficient U was determined by applying specially developed equipment and software. According to the experimental test, the coefficient's U value for the multi-layer construction with the foam polystyrene thermal insulation was found to be 0.36±0.10 W m^{-2} K.

It is well known that acoustic absorption and heat flow indices depend on the pores of the material. It is expected that a material able to acquire the preferable pore structure depending on application will be developed. Up to now, research has been made on foam gypsum acoustic absorption qualities by modifying the foam gypsum material volume density, layer thickness, and production technology. J. Skujāns and R. Brencis are elaborating technology for production of foam gypsum with the predictable structure and performance parameters, providing a weighted average of the sound absorption coefficient of Class C according to the EN ISO 11654:2000 requirements (Skujans, 2010), as well as with sufficient mechanical properties (Brencis, 2011a). Sound absorption ratio of 0.62 was obtained in an impedance tube (sample thickness of 50 mm) corresponding to material class C, and absorption ratio of 0.80 was obtained in a reverberation chamber (sample thickness of 40 mm) corresponding to material class B.

It was discovered (Brencis *et al*., 2011a) that foam gypsum absorption material and mineral wool display analogous behaviour regarding the sound absorption ratio and product thickness. Sound absorption ratio at 250 Hz is higher if thickness of the material is 100 mm; with increase in frequency, the maximum sound absorption ratio is achieved with thinner samples.

Adding of disperse hemp shives reinforcement (size of hemp shives – 2.5–5.0 mm; concentration – 15–50 g per 1 kg of dry gypsum raw material) to foam gypsum increases the bending strength approximately 1.5 times and improves the sound absorption coefficient by 10–15% (Brencis *et al*., 2011b). It has been stated that all the above-mentioned parameters influence the qualities of foam gypsum acoustic absorption, which allows developing such foam gypsum structure that can be used for production of acoustic absorption layers and acoustic insulation panels. As acoustic parameters conform with normative regulations, the use of different acoustic materials in modern civil engineering will continue to increase.

Research on marketing problems of construction products

Economic problems of construction products industry, especially in the field of ceramics products, were S. Gusta's research field at the end of the 1990s. In 2006, she defended her doctoral thesis "Building ceramics in Latvia: Demand and supply problems", and later published her monograph "Building ceramics products in Latvia" (Gusta, 2009). The subject of S. Gusta's research was the demand and supply problem of ceramic building materials and the role of the production of ceramic building materials in the development of construction industry and in the national economy as a whole. The problem was analysed in connection with resources of mineral deposits in Latvia.

Problems of standardization and conformity assessment of construction products in construction industry are on agenda of assoc. prof. A. Steinerts and assistant prof. S. Gusta (Steinerts, 2003, 2009; Gusta *et al*., 2003). By involvement in activities of technical committees for standardization of building materials and by participation in the drafting of legislative proposals and regulations, A. Steinerts and S. Gusta learned the influence of standardization processes as well as implementation of EU directives and role of conformity assessment system in improvement of the quality of building materials and marketing of construction products business (Gusta, Steinerts, 2000; Gusta *et al*., 2002; Gusta, Steinerts, 2005; Krēsliņš *et al*., 2005). Active participation in the process of the development of Latvian standardization system as well as in harmonization and implementation of European legislation was useful and, in later years, enabled effective implementation of Eurocode standards both in training of students and in structural design practice.

The latest research activities of S. Gusta have been focused on sustainable building issues, including industrial energy efficiency, and on climate change influence and recycling problems of building materials (Gusta, Actāja, 2011; Gusta, Skribans, 2012; Gusta, 2012).

Studies on agricultural buildings and envelope structures

Studies on the constructive solutions and layouts of agricultural building have also been topical since the establishment of the Building Department.

In the 1950s–1960s, a lot of attention was paid to research on optimal planning and constructive solutions of the livestock buildings. J. Augstkalniņš, under scientific management of prof. A. Tramdahs, researched issues related to planning of livestock buildings. His research resulted in successful conferment of a scientific degree for investigations of optimal structural planning of piggeries in collective farms (Augstkalniņš, 1955). Practical guidelines and instructions as general conclusions of J. Augstkalniņš' research were published in scientific research papers (Augstkalniņš, 1959) and in a monograph on planning of cowsheds (Augskalniņš, 1960).

The teaching staff of the Building Department – L. Blūma, J. Ģērmanis, J. Šutka, and G. Andersons – as well as research students under scientific leadership of prof. A. Tramdahs and assistant prof. J. Augstkalniņš addressed their investigations to optimization issues of the design of livestock farm buildings and their structures. Under prof. A. Tramdahs management, research student G. Asars examined forage preservation solutions in sealed towers (Asars, Zīrups, 1965). Research student L. Jesperiņš, guided by J. Augstkalniņš, studied possibilities of reconstruction and integrated mechanization options of cattle farms built in the 1960s. The object of L. Jesperiņš' research was layouts, planning and construction solutions, as well as durability of dairy farm structures (Matisāns, Jesperiņš, 1975).

L. Blūma investigated issues related to construction of sound cowsheds' wall structures that would be suitable for Latvian climatic conditions (Blūma, 1971a).

In the 1960s, investigation of floor structures of livestock buildings was carried out by research student K. Rudens, under management of assistant prof. J. Augstkalniņš. By increasing the number of cattle in cattle sheds, it became necessary to increase also the mechanization level in livestock breeding buildings and to find locally appropriate mechanization methods for manure removal and manure storage in these premises.

Teaching staff of the Building Department (G. Andersons), involving also colleagues from the Technical Faculty (S. Timšāns) and from Estonia (V. Masso), studied methods and

practice of collecting slurry in cattle sheds. Research results were summarized in a monograph (Timšāns *et al*., 1969).

Increase in the mechanization level of livestock buildings made it necessary to find new construction and design solutions of these buildings, particularly design of channels for slurry floating (Andersons, 1970). G. Andersons addressed his scientific interest to slot floors, particularly to mechanization of the slurry removal processes in cattle farms (Andersons, Strupulis, 1972). He was directly involved in solving this problem, which succeeded in the successfully defended dissertation "Mechanization of slurry removal of fattening cattle farms" in 1973 (Андерсон, 1973).

Teaching staff of both Departments in cooperation with the researchers of the Building Research Institute and other experts developed a set of technical requirements for livestock building floors. Also assistant prof. G. Andersons took part in studies of floor structures of livestock buildings using composite materials (Файтельсон *et al*., 1983). Research on the use of perlite floor structures was managed by assistant prof. I. Geidāns (Шлейнерс *et al*., 1983). Research on optimization of the floor structures for fattening piggeries was followed up also in the 1990s (Štrausa, 1998).

During the period from 1971 until 1975, the staff of the Building Department (L. Blūma, J. Ģērmanis, and J. Kreilis), under guidance of J. Augstkalniņš (later – under guidance of G. Andersons), carried out research on planning and constructive solutions of forage storage facilities in cattle farms. Recommendations on the design of these facilities were summarized in a research report and in publications. Construction costs as well as mechanization opportunities of forage storage facilities depending on fodder collecting and feeding technology were analyzed. One of the most important conclusions drawn from L. Blūma's studies was that the feed storage towers are a progressive technical solution; however, by solving and rising the mechanization level of forage collection, feed storage sheds can also become competitive compared to feed storage towers (Blūma, 1971b).

From 1976 to 1980, the academic staff of both Departments (O. Liepiņš, A. Šteinerts, I. Geidāns, J. Skujāns, S. Štrausa, J. Kreilis, L. Ozola, J. Mēnesis, M. Žodziņa, etc.), under management of G. Andersons, were involved in the research "The cutting-edge design for livestock buildings and its scientific basis". The study results were summarized in the final report and in scientific publications.

From 1980 to 1985, teaching staff of the Department of Engineering Constructions (R. Bērziņa, J. Kreilis, L. Ozola, L. Pabērzis, D. Ziemele, and I. Geidāns as the responsible executor), under scientific management of G. Andersons, worked on the theme "Improvement of structures of dairy and pig farm buildings". The research results on the use of perlite concrete structures and optimal dimensions of reinforced concrete foundations were published in a scientific report and articles. At the same time, teaching staff and students of the Department of Engineering Constructions (G. Anderons, L. Ozola, L. Pabērzis, D. Ziemele, A. Rubenis, M. Markots, etc.) were involved in the research "Nomenclature of the rational types of timber structures for agricultural production buildings in the Latvian SSR".

In the 1980s, scientific activities on the above-mentioned themes were managed by S. Štrausa. As a result, several methodological and teaching aids ("Dairy farm complex", "Pig farm complex", "Design solutions of agricultural production buildings", "Fattening cattle ranch", "Livestock breeding buildings", "Construction of lightweight type cowsheds", "Farmstead") as well as a monograph (S. Štrausa, 1989) were prepared and published.

Research in a variety of construction areas was carried out by assistant professors O. Liepiņš, I. Geidāns, and L. Sils. Scientific interests of O. Liepiņš were related to the influence of construction mechanization technologies on the construction operation processes on building sites, as well as to the suitability of buildings and their structures for introduction of mechanization of technological processes in the buildings. I. Geidāns together with his colleagues studied the performance and improvement opportunities of the envelope structures of the building production. L. Sils' main research interest was agricultural production structures, mainly greenhouses (Менесис *et al*., 1987), as well as innovative proposals for construction industry (Силс, 1983). L. Sils and I. Geidāns have invented many new patentable technical solutions. They have submitted several dozen patent applications to the Patents Examination Board and have received more than 20 Soviet authorship certificates.

After regaining Latvia's independence, co-operation with regional enterprises expanded, and research in the area of agricultural buildings and structures was characterized by greater involvement in international cooperation, particularly by regular participation in international scientific conferences.

Teaching staff of both Departments (Department of Architecture and Civil Engineering, and Department of Structural Engineering) – J. Skujāns, G. Andersons, J. Kreilis, S. Strausa, A. Vulāns, etc. – as well as prof. U. Iljins from the Department of Physics elaborated methodological guidelines on production and installation of sandwich-type panels manufactured by "Tenax" company (Iljins *et al*., 2004). In subsequent years, the team of researchers, led by prof. U. Iljins, developed the methodological basis of the design and manufacturing of the permanent moulding system for company "Tenax" (Iljins *et al*., 2006).

Specific guidance for application of expanded clay concrete masonry blocks with a thermal insulation intermediate layer for designers and builders was developed (Skujāns *et al*., 2010b). In cooperation with the Technical Faculty of LLU, methodical aid for environmental protection measures in pig breeding houses was elaborated (Bērziņa *et al*., 2003). S. Štrausa, G. Andersons, J. Kreilis, A. Cimermanis, A. Stankevičs, and V. Ščegoļeva developed and published study (Štrausa *et al*., 2008) and methodological (Štrausa, Grants, 2008) aids.

Besides, teaching staff of both Departments (J. Brauns, J. Kreilis, L. Ozola, A. Steinerts, G. Andersons and U. Skadins) were actively involved in the twinning project LV/2005-IB/EC/01 "Implementation of Eurocodes in structural design practice in Latvia" (project co-manager on the side of Latvia – assoc. prof. A. Šteinerts), initiated by the Ministry of Economy and funded by the European Transition facilities program. In cooperation with specialists of the German Institute of Construction Technology (*Deutshes Institut fūr Bautechnik*), the leading experts of structural engineering of the German technical universities trained Latvian academics. Within the frame of the project, many academics improved their expertise in the designing of structures according to Eurocode standards. Implementation of the project resulted in a number of teaching aids in construction design, in several methodological tools for application of Eurocode standards, and in submission of proposals for National annexes (Steinerts *et al*., 2011; Implementation of ..., 2007).

Research on indoor climate and on energy efficiency in buildings

At the Building Department in the 1950s, the research of assistant prof. J. Augstkalniņš on microclimate in piggeries commenced studies on microclimate problems in stockyards (Augstkalniņš,

1958). In the period of concentrating of livestock in large farms, mechanization of manure removal became a topical issue. The air composition in the sheds with mechanical and hydraulic manure removal systems was analyzed. Although the atmosphere was not significantly different, it was recommended to partially drain the air from the slurry channels where harmful gas concentration is higher (Andersons, Hmeļņickis, 1973).

The results of investigations in the field of heat recovery in ventilation systems were summarized in a dissertation work (Лешинскис, 1984). Assistant prof. J. Jurševskis developed an air conditioning system of optimal performance algorithms for systems with indirect evaporative cooling, thus achieving significant energy savings (Jurševskis, 1993).

O. Siņajevs and R. Siņajeva from the Department of Structural Engineering studied thermal performance capacity of glazed structure elements of buildings constructed in the past, as well as opportunities to improve their thermal resistance (Sinyayeva *et al*., 1998).

Professor U. Iljins and other teaching staff in cooperation with the Department of Physics carried out research on energy efficiency in buildings and on minimization of heat losses through the building envelope structures. Such investigations were performed already at the end of the last century. Since there are large heat losses through the foundations of the buildings, a new model for estimation of thermal resistance was developed. This model can be applied for calculations of insulation and for estimation of economical gains of improvement of thermal insulation (Iljins *et al*., 1998). Also research of moisture diffusion in roof structures was done (Iljins *et al*., 2003, 2005b).

Because microclimate and thermal characteristics in cowsheds differ from those in other buildings, S. Štrausa and J. Jurševskis assessed feasibility of envelope structures of cowsheds in accordance with the requirements of the Building Code. It was found that when the temperature is above 10 °C, the essential importance of CO_2 pollution in the air for design of ventilation and calculation of the thermal parameters should be taken into account. If the temperature is below 10 °C, moisture content in the air is essential for calculations. As the most economically attractive wall structure for stockyards, S. Štrausa and J. Jurševskis recommend a 250-mm lightweight concrete block plastered masonry with the outside foamed polystyrene insulation, and for roofing – corrugated bituminous sheets (Štrausa, Jurševskis, 2003).

Theoretical and experimental investigation of designed livestock housings ensures optimal construction solutions from the technical, economical and livestock welfare position. For assessment of energy efficiency and possible construction defects of the existing buildings, the method of thermography was used and measurements of heat flow were performed. By using these methods, exact temperature loads can be defined and calculated; these methods are also suitable for analyzing heat transmission of overground bound constructions (Liepiņš, Štrausa *et al*., 2011).

Investigations of indoor air quality of day care centers and school buildings highlight the problems of sustainability of buildings where partial renovation has been done (Pelīte, Lešinskis, 2003; Krūmiņš *et al*., 2011; Stankevičs, Lešinskis, 2012).

The temperature method elaborated at the Department of Architecture and Civil Engineering provides an opportunity to expand the experimental use of the thermal image camera for determination of heat transfer coefficients for existing external constructions (Liepiņš *et al*., 2012).

Within the frame of Climate Change Financial Instrument project "Climate change mitigation information activities in schools" FICC-8/33 (project manager D. Zigmunde; execution period – 2011), a teaching tool was issued (Štrausa *et al*., 2011). Interest of the teaching staff (J. Kreilis, S. Štrausa, and A. Vulāns) was paid to analysis of thermal transmission in envelope structures of buildings. The results were reported in poster format at the conference of Northeast section of American Society for Engineering Education at Bridgeport University in 2009.

The teaching staff has been involved also in research on sustainable soil and solar thermal energy use. S. Štrausa in collaboration with the teaching staff of the Faculty of Agricultural Mechanization, under management of prof. E. Bērziņš, researched use of solar power facilities in primary agricultural structures. In the last years of the Soviet period, universal drying facilities with solar collectors for drying of grain and hay were designed and constructed at the LLU Research farm "Vecauce", at the collective farm "Nākotne", and at the farm "Mazkauliņi".

Under management of prof. U. Iljins, a mathematical model and a computer program were developed to evaluate and analyze various soil heat utilization projects with particular parameters of thermal pumps, heat collectors, soil parameters, and climatic conditions. Prof. J. Skujāns and assoc. prof. G. Andersons verified that the developed mathematical model can be applied for any outdoor air temperature and soil thermophysical parameters, which are considered when modifying the approximate coefficients (Iljins *et al*., 2010).

Moisture in building structures increases the losses of heat in its premises. U. Iljins, G. Andersons, and I. Ziemelis carried out experiments on the process of moisture migration in building structures and developed a mathematical model to determine the moisture distribution in building envelopes. The researchers found that vertical waterproofing decking increases the moisture content in walls, which was confirmed also in practical observations of the walls of the Jelgava Palace. Therefore, a horizontal waterproofing membrane should be installed in the walls, and other relevant measures should be undertaken (Iljins et al., 2001, 2002).

Conclusions

Teaching staff of both departments related to the civil engineering science – the Department of Architecture and Construction, and the Department of Structural Engineering – in cooperation with other departments of the LLU are involved in researches on topical issues of Latvian construction industry, taking into account the climatic conditions in Latvia and their impact on indoor climate, especially for animal breading facilities with a high concentration of livestock. Attention is paid to selection of appropriate building materials, finding of constructive solutions and layouts of buildings, use of local raw materials, as well as to application of advanced technology of production and performance on building sites.

The material basis developed at the LLU should be more extensively used in the future. Promising research areas at the Departments are:

- use of construction products made of foam gypsum modified with ecological materials – by-products of agricultural production (hemp stalks, flax sheaves, etc.);
- properties and production technology of building materials and construction products that are produced using environmentally friendly materials and technologies;
- issues pertaining to the EU's research programs;
- passive houses, as well as energy efficiency of buildings and problems related to energy saving technologies.

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The Development and Structure of Research in Landscape Architecture

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Abstract. The landscape architecture as a new branch of science is concerned with a wide range of multidisciplinary research directions, including summary of the results of the processes of the base of nature, environmental infrastructure, territorial planning, cultural history, and the architecture and art synthesis both in urban environment and in landscape space. Researches have made important contributions to the development of urban and rural municipal areas and their infrastructure, comprising also a new strategy related to the three main areas: quality of the environment, social factors, and the economics.
Key words: Compositional and functional structure of landscape space, landscape of urban construction, aesthetic and ecological aspects.

Introduction

The science of landscape architecture at the Latvia University of Agriculture (LLU) is a new research direction. It has evolved starting from the 1990s when scientific work was based on a wide range of multidisciplinary research directions, including summary of the results of the processes of the base of nature, environmental infrastructure, territorial planning, cultural history, and the architecture and art synthesis both in urban environment and in landscape space. The main research directions are related to: preservation of the identity of the cultural historical environment and to the processes of the anthropogenic load; summary and analysis of the green areas of the urban space and of the context issues of the building zones; uniqueness of the Latvian coastal landscape areas and their protection guidelines; and the modernism and avant-garde trends of the modern art, and their synthesis in the cultural landscape. The research is commonly undertaken after earning the Master's degree in Landscape Architecture at the Faculty of Rural Engineering of the LLU or at the Faculty of Architecture of the Riga Technical University.

The beginning of the development of the landscape architecture science

The first studies of the rural space at the LLU are associated with the scientific publications of the architect Jānis Ģērmanis, assistant of the LLU Department of Construction in 1959–1960. He summarized research results on the development of the landscape space of rural cultural historical buildings of Latgale and the specificity of its national identity. In his publications, J. Ģērmanis dealt with the construction traditions of farmsteads and the value of details of the wooden architecture, its preservation, and conservation and restoration possibilities (Ģērmanis, 1960). His research material collected 50–60 years ago is now highly valued by the young landscape scientists on their expeditions to study the landscape space of Latgale (Lazdāne, Markova, 2013).

A rapid progress in the science of landscape architecture began in the 1990s under the leadership of the professor, doctor of geographical sciences Aija Melluma, who gave a professional vision and

development directions for the specificity of landscape architecture, developed scientific reasoning and methodology, and created the basic nature protection theories in Latvia: the Gauja National Park, five protected landscape areas, the cultural–historical area – the Livonian Coast, the North Vidzeme Biosphere Reserve, Talsi Hillock Nature Park, Gaiziņkalns Hill, Nature Park "Daugava bends", etc. The professor has also made a report on the landscape policy in Latvia: situation, problems, and opportunities (Melluma, 2009).

Synthesis and harmony in the transformation processes of landscape space

The research results obtained in the theory of geography and landscape science created a possibility of developing a direction of the next exploratory search related to research of architecturally spatial structure. On the basis of the inter-university agreement between the Latvia University of Agriculture, Agricultural University of Norway (NLH), and Riga Technical University (RTU), an extensive scientific research cooperation was initiated in the late 1990s.

Findings of the research carried out by prof. Karsten Jorgensen (NLH) were strongly aimed at preservation of the historical identity and individuality of the base of nature and landscape space. In his evaluations, prof. Oļģerts Buka (RTU) indicates that scientific activities in landscape architecture should be based on the survey results that reflect the significance of the municipal territorial plan and its contribution to the development of a definite functional area, evaluating the political, socio-economic, and architecturally spatial and landscape aspects (Buka, Briņķis, 2001). Prof. Ivars Strautmanis (RTU) highlights the criteria of form creation expressions of the architectural space that are important to the visually compositional design of the landscape, defining the unity versions of architecture and surrounding environment which are based on the principles of integration and coexistence (Strautmanis, 1977).

The results obtained in the collaborative project provided an opportunity for a new research direction, as well as for Aija Ziemeļniece to defend her academic degree in architecture. She examined the processes that are related to the cultural and historical landscape and that synthesize in themselves interaction between of the base of nature and the economic circulation as well as the artistic and cultural expression form, which, by transforming over the centuries, has created a definite architectural landscape space. Consequently, in A. Ziemeļniece's research, cultural landscape is not judged as a separate part of time and space, but regularities of the historical continuity are analyzed on the fundamentals of synthesis. A. Ziemeļniece's research findings demonstrate that the cultural landscape, similarly to the protection regulations of the cultural historical monuments, requires a specific attitude in developing the requirements of landscape regulation and protection (Ziemeļniece, 2012).

Archaeological research and search of the landscape context

Increasingly more scientists in Europe recognize that environmental quality is a value that serves as a crucial prerequisite for international competition, and as an enhancement of economic development when the spatial environment and quality of life should become the main aim in planning and management of each place. It is also attributable to the study of the oldest inhabited areas, namely, to archaeology, which in the context of landscape space is a new research direction.

Prof. Māra Urtāne together with representatives of the Swedish landscape architecture and philosophical sciences has carried out research that is summarized in a doctoral thesis, so giving international publicity not only to the scientific research but also to the Latvian cultural

and historic landscape in the Baltic region. An international promotion council represented by scientists from the Swedish University of Agricultural Sciences participated in the defence of M. Urtāne's research work (Urtāne, 2001).

Interaction criteria of the urban and rural landscape in the early 21st century

The year 2010 is the beginning of novel and significant contributions made by the young scientists of landscape architecture at LLU. Daiga Zigmunde is the first in Latvia who earned the Doctor's degree in architecture, subdivision of landscape architecture. She examined the issue based on the development of new mansion villages in the vicinity of Latvia's major cities in the early 21st century (Zigmunde, 2010). Regaining of ownership rights in the 1990s created a new landscape structure that, as a result of land division, had a mosaic-type character. The most common landholdings were transformed into mansion building zones, bringing free, sometimes even separate, pieces of land, chaotic in their nature in the landscape. In the landscape space, they appear as strange formations, often developing in the most beautiful scenic areas as uniform, mono-functional objects. Consequently, identity of the traditional Latvian landscape, its identity, and natural and cultural values are threatened. D. Zigmunde's doctoral thesis has a scientific and methodological significance, as it sums up the scientific research and practical methods of landscape architecture.

In a number of studies, landscape architecture as an interdisciplinary science sector has proved to have a close link also with economic science. One of such studies is the research carried out by the Doctor of economic sciences, landscape architect Ilze Stokmane. She gave an overview of the single geographical region of the Baltic countries, each of which has a different territorial division and different life conditions. In the global practice, for the assessment of the national development process it is conceptually assumed that the social and economic environment must gradually grow in the national territory so as the residents in this area would desire to live and work better. Unfortunately, the speed of the development process in different national territories is different and limited in the potential directing development. By mutual collaboration, it is possible to create a quality living environment for residents, promoting regional and national development as a whole, therefore a modern regional development is created as planning of the use of linked resources, and it is inter-territorial. In the current situation, one of the most important tasks of the regional development becomes the improvement of the image of a region and determination of the priority directions and competitiveness factors (Stokmane, 2011).

The research direction of the backyard issues for high-rise residential zones in the urban construction space is a bright example of research on the development of the above-mentioned interdisciplinary science – landscape science. Una Īle, Doctor of architectural sciences, subdivision of landscape architecture, has collected research materials that are significant for a perspective development of the infrastructure of any municipal urban construction space. In these districts in Latvia, gaps in functional zones and technical solutions, load of the parking lot, spatial environment pollution, as well as depreciation of the free places of recreation were observed. Functional, aesthetically harmonious and organized large-scale residential districts can be created by a successful design of the spatial composition (Figure 1). By changes in lifestyle, the perception of the necessity for the public outdoor space has also changed. In the European countries, in the large-scale residential planning there are highlighted two aspects – implementation of the principles of a sustainable development, and changes in the population density of residential areas. Little attention

Fig. 1. The scheme of the development of a large-scale residential area (U. Īle, 2011).

is paid to the large-scale housing fund of the Baltic Sea region, which causes many irreversible development factors for successful development and planning of these districts (Īle, 2012).

The direction of research on **the cultural landscape of historic gardens and parks in Latvia** is an important contribution to the development of landscape planning theory in Latvia, as it serves as a scientifically based encouragement for the local governments and the country in general to have a serious attitude to the quality of the development of cultural–historical environment. The research of Kristīne Dreija, Doctor of architectural sciences in the subdivision of landscape architecture, describes the historic gardens and parks in the context of Latvia and the world, as well as the scientific approaches and the researches carried out before. In the theoretical part of her research, K. Dreija took into account many aspects, such as the garden philosophy, architectural spatial aspects, aesthetic and ecological values of landscapes, and socioeconomic aspects covering tourism as well; an extensive material includes analysis of laws and regulations and trends in sustainable development planning (Figures 2 and 3). K. Dreija successfully integrated the obtained results into the concepts of classification and development of historical gardens and parks (Dreija, 2012).

Avant-gardism trends and stylistics in the cultural landscape as a scientific research theme proves the fact that presence of art elements takes an important place in the interdisciplinary context of landscape architecture. The doctoral student Evita Alle in her research, prepared for pre-defense, has studied the interaction of cultural landscape and contemporary art as a phenomenon,

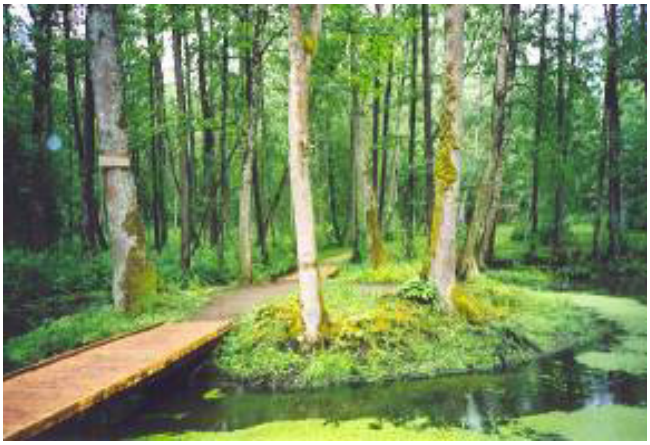
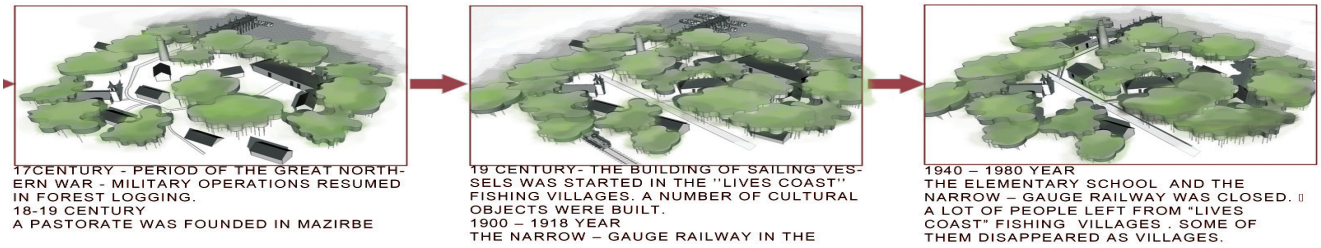


Fig. 2. Love island in the Remte manor park. Wooden bridges without railing. (Photo by K. Dreija, 2008.)

Fig. 3. Love island in the Remte manor park. Wooden bridges set by the Latvian State Forests in 2012. (Photo by K. Dreija, 2013.)



a) b) c)

a) 17th century – period of the Great Northern War – military operations resumed in forest logging. 18th–19th centuries – a pastorate was founded in Mazirbe.
b) 19th century – the building of sailing vessels was started in the "Livonian Coast" fishing villages. A number of cultural objects were built. 1900–1918 – the narrow gauge railway.
c) 1940–1980 – the elementary school and the narrow gauge railway were closed. A lot of people left "Livonian Coast" fishing villages. Some of them disappeared as villages.

Fig. 4. The compositional and functional structure of landscape space (N. Ņitavska, 2012).

its mutual relationships and opportunities for expression. Her research theme covers the contact zone of two main research directions, including the understanding of the public outdoor space in the context of urban planning and the diversity of creation of the contemporary pieces of art in the outdoor space. The phenomenon is studied from the aesthetic, social and environmental aspects (Alle, 2012). E. Alle's research is based on the use of the conceptual and theoretical principles of the interaction of a suitable cultural landscape and contemporary art, as well as patterns and approaches of cognition in general.

Three young scientists have prepared summaries of their promotion theses for pre-defense: Natālija Ņitavska – the uniqueness of the Latvian coastal landscape areas (Figure 4), and

Fig. 5. A catholic church in Latgale.
(Photo by M. Markova, 2013.)

guidelines for their protection; Lilita Lazdāne – the old watermills as a cultural heritage in the landscape space; and Madara Markova – the regional identity research of the places of worship in Latgale (Figure 5).

Silvija Rubene and Gundega Linãre, Master degree holders in architecture, have contributed much to the development of Latvia's landscape architecture.

Cooperation with RTU professors academics J. Krastiņš, U. Bratuškins, I. Strautmanis, S. Treija, G. Asaris, O. Buks, J. Briņķis, professor of the Academy of Arts, President of the Latvian Academy of Sciences, academic O. Spārītis, and art historian, Honorary professor I. Lancmanis has greatly contributed to the science of landscape architecture.

As a result of scientific cooperation, a new scientific journal about research in architecture, landscape architecture, and art industry has been launched. Close cooperation has been established with agricultural universities in Uppsala, Norway, Estonia and Lithuania, with the Saint Petersburg State University of Architecture and Civil Engineering, with the Hochschule Neubrandenburg University of Applied Sciences, and with others.

Conclusion

The scientific studies in landscape architecture are directed to a mutually balanced development of social, economic, ecological, and architecturally landscaped aspects of Latvia's regional environment, as well as to their mutual harmony. The results of the researches are one of the most important components of the territorial environmental planning, addressing quality issues of the human life space in its broadest aspect and ensuring its sustainable development in Latvian planning regions and in their individual areas.

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Looking Back on Science Activities at the Faculty of Information Technologies

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Faculty of Information Technologies

Abstract. The article gives an overview of the development of scientific activities related to information technologies at the Latvia University of Agriculture from the 1960s to nowadays. The Faculty of Information Technologies was founded in 2001, but scientific activities related to information technologies began in the middle of 1960s. In 1967, the Department of Economic Mathematical Methods and Computing Technique (EMM & CT) was established. Its main research interest was use of mathematical methods, and most important tasks were related to optimization of agricultural production and cattle feeding in collective farms. Information technologies were based on the mainframe computers. In 1972, the Department of EMM & CT was renamed the Department of Economic Cybernetics, but later – the Department of Informatics. Several dissertations were presented in that period. In the 1980s, scientific activities were related to the use of personal computers. The Institute of Informatics was founded in the year 1992, and its scientific directions included simulation of modeling methods, tools and expert systems. The Faculty of Information Technologies, founded on the basis of the Institute of Informatics, is now developing new scientific fields.
Key words: Information technologies, computers, mathematical methods, scientific activities.

Introduction

By the end of the 1950s, mainframe computers were introduced in the main universities and scientific institutes of the Republic of Latvia. In 1959, two computing centers were established. The first one was at the Institute of Physics of Science Academy, where the computer LM-3 was installed the following year, and the other one was at the Latvia State University, where the computer BESM-2 was installed (Strazdiņš, 1972).

First attempts to use Economic Mathematical Methods (EMM) and electronic computers in perspective planning of agricultural production in Latvia started in 1965, when main indices of the development of agriculture for Latvia in total and for each region separately were calculated (Bite, Krastiņš, 1967). In 1967, the Economic Institute of Science Academy (EISA) published methodical guidelines on perspective planning of agricultural production by means of the electronic computer BESM-2. The experience obtained in Tukums region served as background for the guidelines (Lauksaimniecības ražošanas …, 1967).

At that time also Latvia Academy of Agriculture (futher in the text – LAA; LAA was renamed the Latvia University of Agriculture in 1991) started its scientific activities in the same field. In the middle of 1960s, researches related to use of EMM and computers were carried out. In the succeeding years, there were other different events and changes that are described further in the article by decades.

The 1960s

In the 1960s, teaching staff of several departments of LAA started to take interest in EMM and electronic computers. Moreover, updated education on computing was required for the students of all faculties of LAA. In order to satisfy these requirements it was decided to join forces of several computing enthusiasts into one department. Thereby, in 1967, the Department of Economic Mathematical Methods and Computing Technique (EMM & CT) was established at the LAA. Docent candidate of technical science Alberts Krastiņš was nominated to head this Department. The following teaching staff of LAA also joined the new Department: docent Austra Brigmane, lecturer Arvīds Brūvers, and lecturer Haralds Kauss. All the above-mentioned staff previously had worked at the Department of Higher Mathematics. Lecturer, Candidate of agricultural science Aina Ratkeviča joined the new Department from the Department of Economics of the Faculty of Agriculture, assistant Zinta Ziediņa came from the Department of Statistics and Accounting, lecturers, candidates of agricultural science Uldis Štibe and Auseklis Zemītis came from the Faculty of Forestry (Lauksaimniecības ekonomikas …, 1982). The new Department staff lectured on the following subjects: EMM, computing technique in engineering and economic calculations, mathematical statistics, and theory of probability.

In 1968, the Faculty of Economics of Agriculture (headed by the Dean Voldemārs Strīķis) was founded on the basis of several departments of the Faculty of Agronomy; the Department of EMM & CT was made as part of this Faculty (Ekonomikas augstākā …, 2003). In this Department, the students were acquiring skills in using the counting frames, logarithmic rules, mechanical and electromechanical calculators, accounting machines, and punch card machines. The teaching staff of the Department of EMM & CT provided the basics of computing techniques for the students of all LAA's faculties.

The Department staff carried out research work: A. Krastiņš investigated methods of mathematical programming, A. Ratkeviča analyzed the planning and usage of forage, A. Brigmane – usage of statistical methods in predicting the productivity of cereals, and A. Brūvers – optimization of the size and location of stock-farms.

In 1969, student Aleksandrs Gailums (author of this article) defended his diploma paper about using EMM in the planning process of forage utilization (headed by A. Ratkeviča). This mathematics task was solved by using the mainframe computer BESM-4 that was placed at the Latvia State University (LSU). The information of collective farm "Draudziba" in Bauska region served as background for this task (Ratkeviča, 1970).

The Informative Computing Center of the Ministry of Agriculture (ICCA) was established (managed by director H. Kauss) in 1968. The aim of this Center was to find the solutions for tasks related to management of agriculture. The data was processed by the mainframe computer "Minsk-22". After graduating the LAA, A. Gailums, A. Priedīte and V. Klešnieks started to work at the Department of Optimization. The employees of this Department worked under supervision of A. Sproģis, a researcher of EISA.

The farm "Zaļenieki" was the first farm where experiments on the optimization of agricultural production were done. The experiments proved that a computer is preferred for perspective planning. The new methods gave possibility of working out several solutions and choosing the best or the optimal version. The optimal solution provided that the production resources and branches are balanced. Therefore employees were set free from an exhausting work and they could pay more attention to analyses.

The 1970s

In the 1970s, a new period started. Instead of the experiments of optimization plans, new methods were permanently introduced in many farms. The paper worked out at the Economic institute and ICCA helped to manage this process (Kolhozu un …, 1971). The new process anticipated that the specialists in the farms had to fill in the information tables. Later they were gathered and summarized into a standard matrix in the computer. The researchers A. Gailums, Ē. Indāns, V. Klešnieks and A. Priedīte did methodical work for this process. In the 1970s, several software packages of planning and accounting were introduced in the collective farms. The most important packages included farm accounting, registration of traumatism, optimization of agricultural production, optimization of cattle feeding, optimization of herd work, and optimization of fertilizer use (Kipere, 1971).

In 1972, the Department of EMM & CT was renamed the Department of Economic Cybernetics. This department was headed by docent A. Ratkeviča (1972–77, and 1984–86) and docent A. Brūvers (1978–83).

The computer "Minsk-22" provided vast possibilities for the research work of the LAA's staff and students. For example, A. Ratkeviča investigated optimization of forage stocking farms in the winter period as well as optimization of the food ration for cattle (Ratkeviča, 1970); A. Brigmane started to use the statistical methods (correlation analyses, covariation analyses) for forecasting of cereal productivity (Brigmane, Gūtmane, 1975). She also wrote the article "Biometric methods in selection", where she discussed researches on standard deviations, variations, coefficient of correlation, and analyses of dispersion (Lindermanis, Brigmane, 1970).

The researches of A. Brūvers were related to the expert estimate methods used for forecasting the efficiency of agricultural production (Brūvers, 1977). He used the computer Nairi-S for data processing. U. Štibe investigated optimization of the use of mineral fertilizers on farms (Štibe, 1973). A. Krastiņš' research interest was teaching of mathematical programming in agricultural high schools (Krastiņš, 1975). A. Brūvers (Brūvers, 1970) and A. Brigmane (Brigmane, 1972) defended their theses of the Candidate of economics science.

In 1974, the 29th Scientific Conference of LAA took place. A. Ratkeviča chaired the section of Economic Cybernetics. The researchers presented the findings of this Department. A. Gailums and A. Sprogis (EISA) reported on the development of automatic planning system in agriculture of Latvia (LLA 29. zinātniski …, 1974).

In 1975, A. Gailums was transferred from ICCA to the Department of Economic Cybernetics to work as an assistant. A. Gailums delivered lectures and practical works in the course "System of automatic data processing" and "Computer technique in engineering-economic calculations". His researches were related to optimization of perspective planning in farms.

In 1976, two textbooks were published: "Mathematical modeling of agriculture" by A. Ratkeviča (1976) and "Mathematical programming" by A. Krastiņš (1976). In 1979, A. Brūvers produced the teaching material "The basics of programming for the computer the Nairi-S" (Brūvers, 1979).

In the 1970s, several automatic management systems related to agriculture were implemented. For example, information system "Selex" for herd-work of cattle was launched (Arhipovs, 1979). A group headed by prof., Doctor of Economics B. Treijs researched the use of linear programming in agricultural perspective planning.

The 1980s

At the beginning of 1980s, mainframe computers were replaced by personal computers, therefore all tasks had to be adjusted to the specifics of personal computers.

Working places in the collective farms were automated. For example, in the mid-1980s, the Robotron 1720 in the collective farm "Taurene" of the district Cēsis performed several accounting tasks: cattle breeding accounting, electrical resources accounting, storehouse accounting (Strauts, 1987).

At the same time, also the Department of Economic Cybernetics installed the first personal computers: Robotron-1715, Iskra-1817 and Pravec, later followed by IBM PC. Also minicomputers, such as Nairi-3, Nairi-S, Iskra-226, and programming calculators were used. The laboratory of the Department of Accounting used the minicomputer M-5010. Mostly the programming language BASIC was used.

All teaching staff took part in on-line learning courses of BASIC. The students mastered different Office applications: word processor, spreadsheet, and databases. The subject "Informatics" was delivered for students of all faculties. The tasks of food ration optimization were adopted for the computers Pravec, Iskra-226 and CM-4. The methodics was made and introduced by researcher A. Ivane.

The Department staff continued the scientific researches. A. Brigmane researched how to improve the function of grain production (Treijs, Brigmane, 1980), and A. Brūvers analyzed the factors of the experts' estimations (Brūvers, 1980).

A. Gailums defended his Doctor's thesis, which was supervised by professor B. Treijs (Gailums, 1981). An economic mathematical model was solved on the computer "Siemens 4004" at the State Planning Institute in the city of Riga. The data forecast for the model was solved on Nairi-S.

A. Ratkeviča defended her Doctor's habil. thesis of economics science on the subject "Planning of forage with electronic computers" (Ratkeviča, 1989).

In 1987, the Faculty of Agricultural Economics moved out of the main LAA building to a new place, but the Department of Economic Cybernetics, now subordinated to the Rector of LAA, remained in the main building. The head of the Department of Economic Cybernetics was docent J. Beidermanis.

In the same period, ICCA moved to the premises of the Ministry of Agriculture in Riga. Thereby Department of Economic Cybernetics occupied these rooms in basement of the palace.

The 1990s

In 1990, the Department of Economic Cybernetic was renamed the Department of Informatics. Prof., Dr.habil.sc.ing. P. Rivža, who was managing the Department of Mathematics at that time, was nominated as head of the Department of Informatics.

In the year 1992, on the basis of the Department of Informatics, the Institute of Informatics was established. The Institute included the Department of Informatics, the Department of Mathematics, and three divisions: Division of Information Systems, headed by V. Birkants (1992–93), A. Ivane (1993–98), and S. Sproģe (since 1998); Division of Computer Network Service, headed by A. Paura; and Centre of Information Technologies, headed by Ģ. Kazainis. The director of the Institute of Informatics was Dr.habil.sc.ing. P. Rivža (Rivža, 1999).

Research carried out at the Department of Informatics included such subjects as informatics, theory of probability and mathematical statistics, quantitative analysis methods, econometrics,

programming language HTML, Web pages, control systems of databases, and communication technologies. In the premises of the Institute, a new internet classroom was set up.

Two doctoral theses (Arhipova, 1994; Āboltiņš, 1993) and one doctoral habil. thesis (Rivža, 1995) were devoted to the problem of mathematical modeling of the grain drying and storage processes. In 1999, L. Paura defended her Doctor's thesis on elaboration of a model for pedigree bulls' estimation (Paura, 1999). L. Ramute's research theme was use of cluster analysis in grouping of rural municipalities (Ramute, 1996).

Several methodical materials were issued: "Microcalculators programs of counting for agriculture" (Rivža, 1993), "Programming of the microcomputer Electronic B3-34" (Ziediņa, 1993), "Working with word processor MS Word 6.0" (Gailums, Dmitrijeva, 1996), and "Working with spreadsheet MS Excel" (Gailums, Dmitrijeva, 1999).

Cooperation expanded with Estonia, Lithuania, Sweden, the Netherlands and Italy.

In this period, many private farms were established as a result of the Land reform. The farmers as computer users became increasingly involved in the process of information exchange through personal computers, which are a powerful tool for data processing and problem solving.

In January 1991, the Ministry of Agriculture established the Latvia Agricultural Advisory and Training Center. Its purpose was to provide training and consultation for farmers and rural entrepreneurs, as well as to offer such software packages as optimization of food ration, optimization of fertilizers, and accounting for private farms.

The 2000s

In the study year 2000/2001, the Institute of Informatics introduced the academic Bachelor study program "Computer Control and Computer Science". In its elaboration assisted prof. J. Grundspeņķis, Dean of the Faculty of Automatic and Computer Technique of the Riga Technical University.

Assoc.prof. U. Smilts, vice president of the company "Exigen Services Latvia" shared his expertise in elaboration of the professional Bachelor study program "Programming", which was launched the next study year – in 2001/2002.

Both study programs initiated the foundation of the Faculty of Information Technologies (FIT) in 2001. The FIT was established on the basis of the Institute of Informatics. The deans of the Faculty were prof. P. Rivža (2001–02), prof. I. Arhipova (2002–08), and presently, since the year 2008, – prof. U. Iljins.

The Department of Informatics was divided into two departments: Department of Computer Systems, headed by assoc.prof., Dr.oec. A. Gailums (2001–06) and assoc.prof., Dr.sc.comp. R. Čevere (since 2006), and Department of Control Systems, headed by assoc.prof., Dr.sc.agr. L. Paura. The FIT also included the Department of Mathematics, which was headed by prof., Dr.sc.ing. A. Āboltiņš (1990–2007) and prof., Dr.sc.paed. A. Zeidmane (since 2008), and the Department of Physics, headed by prof., Dr.habil.sc.ing. U. Iļjins (1994–2008) and assoc.prof., Dr.sc.ing. U. Gross (since 2008).

In 2005, the Master study program "Information Technologies" was introduced. A significant event in the life of the Faculty was in the year 2006, when the first graduates of the FIT Master study program started their studies in the newly developed Doctoral study program "Information Technologies".

The FIT was organizing different international scientific conferences. The first two (in 2004 and 2006) were held under the title "Information and communication technologies for rural development". Since 2008, the conferences are titled "Applied information and communication technologies".

Within the framework of collaboration between the Forest Faculty and the FIT, an interdisciplinary team of researchers from the scientific disciplines of information technologies and forestry was established. Jointly with the Faculty of Rural Engineering, the qualities of a foam plaster and other molded building materials are being researched. The FIT is cooperating also with the Institute of Microbiology and Biotechnology of the University of Latvia (Stalidzāns, Arhipova, 2009). The project "ICT-AGRI", which has been implemented within the 7th framework program in the period of 2009–2013, provides an opportunity to integrate into the relatively specific sphere of agricultural application of information technologies at an international level.

The Department of Mathematics has close cooperation ties with the Faculty of Mathematics of the Estonian University of Life Sciences. The Department of Physics has concluded a cooperation agreement with Aleksandras Stulginskis University in Lithuania. Besides, all the departments of the FIT are closely collaborating with such employers as SIA "Exigen Services Latvia", SIA "Lattelecom Technology", and SIA "Microsoft Latvia".

The four FIT departments offer a variety of scientific subjects. The main activities of the Departments are described below in the article.

The main directions of scientific activities at the Department of Computer Systems are: computer control systems (leading researcher – E. Stalidzāns): systems and synthetic biology (leading researcher – E. Stalidzāns), development of information and communication technologies in Latvia (leading researcher – P. Rivža), program engineering (leading researcher – R. Čevere), agricultural information systems (leading researcher – A. Gailums), modeling of forestry planning and management (leading researcher – I. Šmits), model-based precision computer control of the multiobject biosystem (leading researcher – A. Zacepins), modeling of autonomus hybrid power supply control systems (leading researcher – V. Osadčuks), and cross-cultural Web information systems design (leading researcher – G. Vītols).

At the Department of Control Systems, the main directions of scientific activities are: applications of information technologies in forestry (leading researcher – I. Arhipova), bioinformatics (leading researcher – L. Paura), methods of statistics and region analyses (leading researcher – L. Ramute), and modeling of waste pollution (leading researcher – L. Bērziņa).

At the Department of Mathematics, the main directions of scientific activities are: pedagogics (leading researcher – A. Zeidmane), modern elementary mathematics and didactics of mathematics (leading researcher – L. Ramāne), and educational management (leading researcher – A. Vintere). Professor emeritus, Dr.silv. R. Ozoliņš has been carrying out research into the forestry science already since 1970, and in 2007 the Ministry of Agriculture of the Republic of Latvia awarded R. Ozoliņš "Gold Cone", the highest award in forest industry, for his lifetime contribution to the development of the forest science in Latvia.

The main directions of scientific activities at the Department of Physics are: heat and mass transfer (leading researcher – U. Iljins), research on solar collectors (leading researcher – U. Gross), and influence of physical parameters of atmosphere on the use of solar energy in several collectors (leading researcher – I. Pelēce).

Since its foundation, 13 staff members of the FIT have defended their doctoral theses: U. Gross (2002), L. Ramāna (2004), E. Kopeika (2007), L. Ramute (2008), N. Sergejeva (2010), S. Atslēga (2011), I. Pelēce (2011), V. Vronska (2011), V. Osadčuks (2012), I. Gedrovica (2012), I. Mozga (2012), G. Vītols (2012), and I. Dukulis (2013).

In 2010, the Promotion Council of Information Technologies was founded. It consists of assoc. prof., Dr.sc.comp. R. Čevere (head of the Council), prof., Dr.sc.ing. I. Arhipova, assoc.prof., Dr.sc.ing. E. Stalidzāns, assoc.prof., Dr.oec. A. Gailums, prof., Dr.habil.sc.comp. J. Borzovs (LU), prof., Dr.habil.sc.ing. J. Grundspeņķis (RTU), assoc.prof., Dr.sc.comp. J. Vīksna (LU), and the scientific secretary of the Council – T. Tabunova. The first promotion theses for acquiring the doctor's degree in the field of information technology were defended in the year 2012 – by I. Mozga (2012) and by A. Cīrulis (2012).

Conclusions

Scientific activities at the Faculty of Information Technologies (FIT) have been closely linked to the development of computing techniques and to the changes in rural areas.

Since its origin in 1967, the number of the FIT teaching staff has considerably increased.

Development of the present Faculty of Information Technologies can be divided into several stages: establishment of the Department of Economic Mathematical Methods and Computing Technique, which later developed into the Department of Economic Cybernetics, afterwards – into the Department of Informatics, then – into the Institute of Informatics, and, finally, into the Faculty of Information Technologies.

In the field of science, the FIT is successfully cooperating not only with other faculties of the Latvia University of Agriculture and with other higher educational institutions of Latvia, but also with its partners in Europe and in the world.

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Artificial Intelligence – the Research Field that Stimulates Collaboration of RTU and LLU in Computer Science

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Abstract. The paper is dedicated to the 150th anniversaries of two universities – RTU and LLU and concerns the research field of artificial intelligence (AI) that stimulates collaboration of both institutions. A brief overview of historical periods of the development of AI is presented. The research activities in AI carried out at the Department of Systems Theory and Design, which are conducted by the author, are described. The collaboration in education and research between the Faculty of Computer Science and Information Technology of RTU and the Faculty of Information Technologies of LLU are outlined. It is shown that at the moment common interests in robotics is the foundation for joint actions.
Key words: Artificial intelligence, intelligent agents, multiagent systems, robotics.

Introduction

The purpose of this paper is twofold. First, taking opportunity that the last year Riga Technical University (RTU) celebrated its 150th anniversary and this year the same jubilee has Latvia University of Agriculture (LLU), it is shown how from the first glance so remote research field as artificial intelligence (considering the basic activities of both universities) stimulates collaboration with long-range perspective. From this aspect, a brief historical overview of artificial intelligence and the research in this field at the Department of Systems Theory and Design of RTU is given. Second, joint actions and future perspectives are described.

Artificial intelligence (AI) is a big field and has serious challenges. Sometimes AI is compared with traditional fields of science such as mathematics, physics or mechanics, and the conclusion is made that if students in the traditional fields rather soon may understand that fundamental laws are already discovered, the AI is waiting for hundreds of Einsteins. Of course, in Latvia it is impossible to explore the full breadth of the field which encompasses crisp and uncertain knowledge representation, perception, reasoning, learning and action, and everything from microelectronic devices to robotic planetary explorers (Russell and Norvig, 2010). That is why local researchers are centred on specific subfields of AI. For example, neural networks, genetic algorithms and data mining are the subjects of research carried out at the Institute of Information Technology of RTU and at LLU. At the Artificial Intelligence Laboratory of LLU, the natural language processing problems are investigated. The broader spectrum of AI problems is explored at the Institute of Applied Computer Systems of RTU and at one of its departments – Department of Systems Theory and Design (DSTD), in particular. More details will be given in the third section. It is worth to mention that some good examples of collaboration of universities in Latvia in the field are also the reality. Thus, for instance, the researchers of the Institute of Mathematics and Computer Science of the LLU together with their colleagues from the DSTD are working on knowledge modelling and representation problems including ontologies. Another good example of cooperation between universities is the subject of this paper.

The paper is organized as follows. In the next section, the brief description of historical periods of development of AI is presented with the purpose to give flavour of the field. Trends of modern approach to AI are also discussed. The third section is dedicated to AI research at the DSTD conducted by the author of this paper. In the fourth section, the collaboration of RTU and LLU in the field of robotics is described. Conclusions contain opinion about benefits of joint actions and outline the perspectives of future collaboration.

The brief history of artificial intelligence research

Regardless of the relatively short history of AI, it is not easy to give a brief summary of it. First of all, the disciplines that contributed ideas, paradigms and techniques to AI must be listed. The main disciplines are the following (Russell and Norvig, 2010):

- philosophy which tries to find answers to such relevant questions as: where does knowledge come from, how does the mental mind arise from a physical brain, and can formal rules be used to draw valid conclusions?
- mathematics which efforts to answer the questions: what can be computed, what are the formal rules to draw valid conclusions, and how to reason with uncertain information?
- economics putting forward several important questions such as how to make decisions so as to maximise payoff which may be far in the future, and how to do this when others may not go along?
- neuroscience with the central question: how do brains process information?
- psychology trying to answer the question: how do humans and animals think and act?
- computer engineering which focuses on the problem how to build an efficient computer;
- control theory and cybernetics which attempt to answer the question: how can artefacts operate under their own control?
- linguistics dealing with natural language processing and aiming to understand how does language relate to thought.

With such background of disciplines it is easier to cover the development of AI itself. In the literature one can find discordant opinions how to divide the history of AI into periods (see, for example, Luger, 2005, and Russell and Norvig, 2010). In this paper, Russell and Norvig's division is followed.

The first period (1943–1955) is called the gestation of AI, when the first work that is now generally recognized as AI was done by W. McCulloch and W. Pitts, who in 1943 proposed a model of artificial neurons. D. Hebb in 1949 demonstrated a simple updating rule (now named as Hebbian learning) for modifying the connection strengths between neurons. The first neural network computer was built in 1950 by two undergraduate students M. Minsky and D. Edmonds at Harvard University. A. Turing was first who articulated a complete vision of AI in his 1950's article "Computing machinery and intelligence", introducing the Turing test, machine learning, genetic algorithms, and reinforcement learning.

The term 'artificial intelligence' was coined by J. McCarthy in 1956, and it happened during the period of early enthusiasm and great expectations (1952–1969). These early years of AI were full of successes. Let's mention only a few: A. Newell's and H. Simon's reasoning programs "The Logic Theorist" and "General Problem Solver", as well as their famous physical symbol system hypothesis, which states that 'a physical symbol system has the necessary and sufficient means for general intelligent action'. Besides, in 1958, J. McCarthy defined the high-level language Lisp – the

dominant AI programming language. Early work on neural networks helped F. Rosenblatt to build the perceptron that could perceive and learn to recognize environmental objects.

But soon AI researchers get so called dose of reality (1966–1973) because several kinds of difficulties arose. First, most early programs contained little or no knowledge of their subject matter. In fact, they succeeded by means of simple syntactic manipulations. The second kind of difficulty was the intractability of many of the problems that AI was attempting to solve by trying out different combinations of steps until the solution was found. This strategy worked rather well in worlds like so called 'block world', which contains very few objects, and, as a consequence, requires very few physical actions and very short solution sequences. The same difficulty with limited computational power faced also researchers who made experiments in machine evolution (now called genetic algorithms). The idea was based on making appropriate series of small mutations to a machine code program and the belief that in result one can generate a program with good performance of any particular simple task. A third difficulty arose because of some fundamental limitations on the basic structures used to generate intelligent behaviour (perceptrons could learn anything they were capable of representing, but they could represent very little, and the results did not apply to more complex, multilayer networks).

The next decade (1969–1979) is known as the decade of knowledge-based systems. Researchers started to use more powerful domain-specific knowledge that allows larger reasoning steps and can more easily handle typical cases in narrow areas of expertise. The new methodology of expert systems was applied to different areas of human expertise. Such expert systems (programs in fact) as DENDRAL for inferring molecular structure from the information provided by a mass spectrometer, MYCIN for diagnosis of blood infections, and SHRDLU system for understanding natural language are only three examples. The widespread growth of applications to real-world problems caused a concurrent increase of knowledge representation schemes, and a large number of different knowledge representation and reasoning languages were developed. Some were based on logic (Prolog or PLANNER, for instance), others, following M. Minsky's (1975) idea of frames, adopted a more structured approach.

At present it is obvious that from 1980 AI becomes an industry after the first successful commercial expert system R1 helped configure orders for new computer systems. By 1988, there were hundreds of expert systems already deployed and much more under the development. So called connectionist models of intelligent systems enabled the return of neural networks. From the scientific point of view, AI becomes a science at the end of the 1980s, when in terms of methodology AI has finally come firmly under the scientific method. To be accepted, hypotheses must be subjected to rigorous empirical experiments. The results, in their turn, must be analysed statistically for their importance. Now it is possible to replicate experiments using the Internet and shared repositories of test data and code. This is the hallmark of knowledge representation, computer vision, neural networks, speech recognition, and robotics as well. A better understanding of problems combined with increased mathematical sophistication followed by formalisation and specialisation has led to workable research agendas and robust methods, but in many cases also to fragmentation, especially in such topics as vision and robotics, which are increasingly isolated from other research directions of AI. The unifying view of AI as rational agent design is one that can bring unity back. The work on SOAR is the best-known example of complete agent architecture. It helps to understand the working of agents embedded in real environments with continuous sensory inputs (vision, sonar, speech recognition, etc.).

In conclusion of this brief history of AI, let's touch on the questions: what can AI do today, and what approaches are used at present to build intelligent entities? First of all, one must understand that one of the most important environments for intelligent agents is the Internet. AI systems have become common in Web-based applications; AI technologies underlie many Internet tools, such as search engines, recommender systems, and Web site construction systems. Due to a huge variety of subfields, only few applications are listed: autonomous planning and scheduling, game playing, autonomous control, natural language understanding, problem solving, diagnosis (medical diagnosis, in particular), logistics, and robotics.

As AI currently encompasses very many different directions, and systematises and automates intellectual tasks, it is natural that there are various definitions of AI. Russell and Norvig (2010) grouped all definitions found in eight text books into four groups:

- systems that think like humans;
- systems that act like humans;
- systems that think rationally;
- systems that act rationally;

It is worth to stress that historically all four approaches to AI have been followed and some tension exists between approaches centred around humans and those centred around rationality. The first measures success of AI systems in terms of human performance, whereas the second measures against an ideal concept of intelligence which is called 'rationality' or, in other words, 'doing the right things given what the system knows' (Russell and Norvig, 2010).

Research in artificial intelligence at the Department of Systems Theory and Design

The first research activities in AI at the DSTD started in late 80s of the previous century. Within the framework of topological modelling – the original approach for description of complex system functioning founded by professor J. Osis (1969), the author of this paper started to study problems of knowledge acquisition and representation. These studies which were carried out together with several doctoral students later were extended to the novel, so called structural modelling approach, and such problems as construction of deep knowledge rule base and various types of reasoning were solved (Grundspenkis, 1999). In structural modelling, the systematic four-step procedure is used for construction of four models of complex heterogeneous systems (Grundspenkis, 1993). Modelling is based on the idea that problem domain expert's knowledge is acquired as small and independent knowledge units representing elements and their relationships of system under investigation. The first model – model of morphological structure (MSM) – consists of related primitives (objects) of developed graphical representation language (an example is shown in Figure 1).

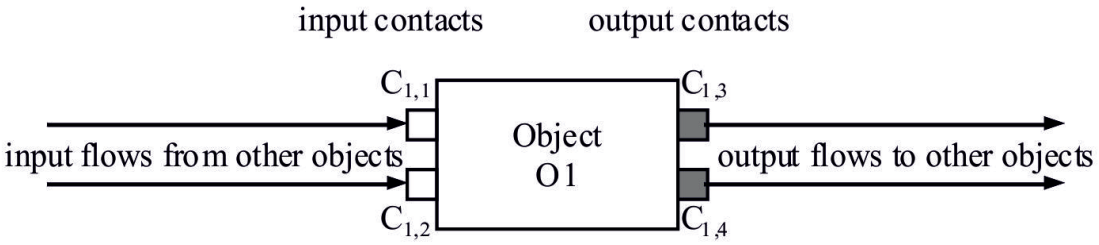

Figure 1. An example of object's graphical representation.

Object output flows characterise their functions. The algorithm of formal transformation of the MSM into the functional model in space of functions (FSM FS) was developed based on transformation of vertex graph into an arc graph (variety of transformations have been described by I. Zeltmate (2012)). Each function may be replaced by a pair of behaviour states of two directly connected contacts. Functions and behaviour states are qualitative characteristics which allow to comprehend and to reason how a system performs in a normal operation mode. As one of the main purposes of structural modelling is support of diagnostic problem solving, the functional model in parameter space (FSM PS) is needed. The notion 'parameter' is used to describe measurable or observable quantity or quality, for example, the pressure at the output of pump. In fact, the FSM FS and the FSM PS speaking in terms of directed graphs are isomorphic because in both models the arcs represent cause–consequence relationships, and semantics of vertices is functions or behaviour states and parameters, correspondingly. Observation of parameter values gives information about system's states which change when parameter values change. Parameter values can change if some faults in the system appear. Possible faults and their caused symptoms are introduced in the fourth model – the extended functional model in space of parameters (eFSM PS).

As it is not possible to describe the structural modelling approach in all its richness, only a short overview of the essence of knowledge representation and reasoning implemented within the framework of this approach follows. First, it is needed to mention that if during the transformation of the MSM into the corresponding directed graph (digraph) semantics of objects and flows between objects is maintained then the latter corresponds to well-known semantic network in AI (Luger, 2005). However, semantic network cannot capture all semantics of MSM, FSM FS, FSM PS, and eFSM PS. It is the reason why for structural modelling, frames first introduced by M. Minsky (1975) were chosen as the most suitable knowledge representation schema. A frame hierarchy in structural modelling differs from the traditional one. The main relationship 'is a' which defines a hierarchy is used, but the second hierarchy is defined by 'part of' relationship. In this hierarchy each contact slot of object frame contains a reference mark to the subframe of this contact in which, in its turn, is a slot corresponding to a behaviour state of contact and a reference mark to a behaviour state frame. The latter contains description of a parameter (its semantics and description of internal and/or external relationships). In diagnostic tasks fault names are added reference marks which are given in the appropriate parameter slot. In this way, frame hierarchy used in structural modelling fully represents knowledge about a system under investigation. This knowledge is visualised using all four abovementioned structural models, and the knowledge base is called a topological knowledge base.

The architecture of the knowledge base has two layers. At the conceptual layer, knowledge is captured into all four structural models and used data structure corresponds to digraphs represented, as a rule, with adjacency matrices. At the implementation layer, production (IF … THEN …) rules are used which are derived from structural equations (another form of graph representation taking into account semantics of vertices and arcs). In practice, there are four sets of production rules – one for each of the structural models.

There are several kinds of reasoning (forward and backward chaining) supported by structural models. The MSM supports so called structural reasoning which enables conclusions about direct and indirect relationships between objects as well as carrying out qualitative and quantitative analysis of structures. The main result of analysis is the determination of structural importance of elements, which shows their roles in normal operation mode as well as consequences of their malfunction.

Reasoning procedures for FSM FS and FSM PS also have been developed which support knowledge acquisition about system's operation in normal conditions. For diagnostic problem solving, several reasoning procedures have been developed, namely, reasoning about system behaviour (based on the FSM FS and using fuzzy logic) and causal reasoning (based on the eFSM PS) which allows to find, localise and diagnose faults. Causal reasoning is supported by deep knowledge rule base which contains cause–consequence rules. These rules substantially differ from traditional production rules and are obtained in result of decomposition of the FSM PS into event trees. Thus, contrary to commonly used production rules that describe shallow knowledge (fault directly related to symptom), cause–consequence rules contain full sequence of parameter value changes starting from a fault and ending with measurable or observable symptoms. It is worth to stress that causal reasoning includes diagnostic reasoning (giving answer to the question why a particular symptom is detected) and predictive reasoning (giving answer to the question what happens if …, that is, establishing consequences caused by a given fault).

For structural model construction and visualisation, the I4S tool has been developed by I. Zeltmate (2012) in her doctoral thesis. In total, five researchers (including the author of this paper) received their doctoral degree after the defence of thesis in the field of structural modelling. Many examples and details of structural modelling as intelligent approach to topological modelling are described in the second part of the monograph which the leading researchers of topological modelling – professors J. Osis, J. Grundspeņķis and Z. Markovičs (2012) – dedicated to the 150th anniversary of RTU.

Intensive research in AI has been done also in several projects (scientific grants) financed by Latvian Council of Science. The four-year project "Intelligent multi-level meta-model processing system for construction of structural modelling methods and tools", which started in 1997, not only was focused on improvement of model transformation algorithms and reasoning procedures including case-based reasoning, but also built the foundations of introduction of time dimension into the FSM PS, usage of ontologies for representation of knowledge structures, and application of structural modelling in knowledge management. Among the main results of this project, also the following should be mentioned: modelling of fault propagation and development of graphical interface for expert's knowledge input into the frame system.

During the work on the project "Modelling of intelligent agent co-operative work for knowledge management and process reengineering purposes in organisations" (2001–2004), research started to focus on advanced approach to AI – intelligent agents. The first results have been obtained, such as refining of agent-based conceptual model of organisation, and development of conceptual model of knowledge worker whose environment includes various types of intelligent agents. Besides, the novel model of intelligent memory of organisation which consists of seven layers has been proposed. This model supports multiagent cooperative work and was foreseen for educational purposes. Knowledge workers' (students') workplaces contain intelligent agents, and lecturers' work is supported by intelligent environment which also includes intelligent agents. Implementation of this model has been started, but due to the shortage of finances was not completed.

Previously get results allowed to propose the new project "Integration of intelligent agent and knowledge management techniques for intelligent support of learning processes" (2005–2008). This was the period when also internal scientific projects of RTU and joint projects of the Ministry of Science and Education and RTU were worked out. The development of concept map based intelligent knowledge assessment system (the IKAS) started (Anohina and Grundspenkis, 2006). The IKAS

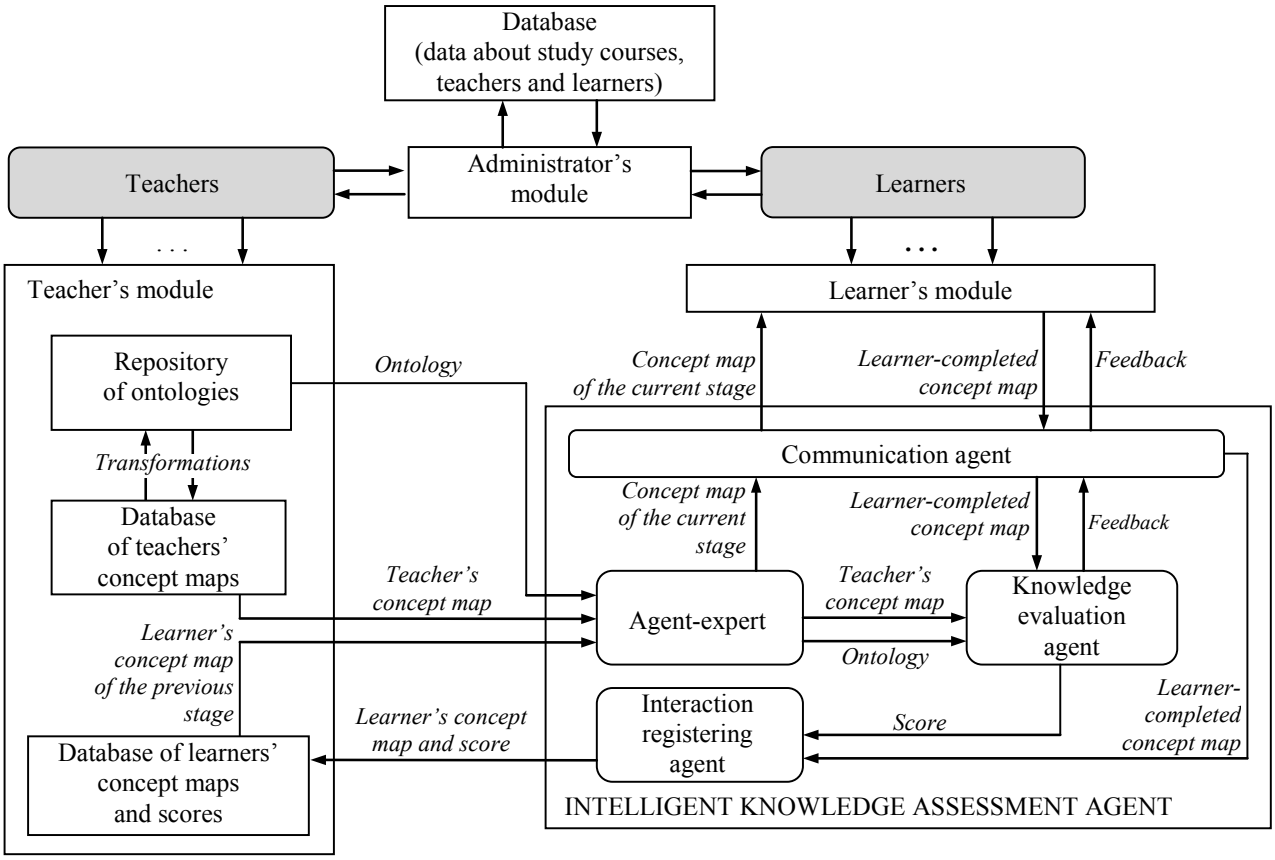

Figure 2. The architecture of IKAS.

constantly evolves based on student given feedback about its functionality, and four versions were developed. Nowadays, the IKAS has rather many unique qualities compared with other systems of this category. The most relevant are: flexible scoring system based on so called graph patterns, possibility to change the degree of task difficulty, feedback for learner with highlighted mistakes, help (explanation of concepts and statistics about differences between teacher's and learner's concept maps). The IKAS is the Internet-based system which is implemented using the following technologies: Eclipse 3.2, Apache Tomcat 6.0, PostgreSQL DBMS 8.1.3, JDBC drivers, Hibernate, VLDocking, JGoodies, and JGraph. The IKAS architecture is depicted in Figure 2 (Grundspenkis, 2011).

Research shows that despite the fact that AI and knowledge management are two research fields that are directly related to acquisition, capturing, processing, usage and dissemination of explicit knowledge, the usage of knowledge management in education is undeveloped. This was the motivation to work out the conceptual framework for integration of the IKAS and personal knowledge management systems (both based on intelligent agent paradigm). Using the systems approach, the two layer framework has been developed, which is shown in Figure 3 (Grundspenkis, 2012).

It is needed to mention that the 2005–2009 period was very prolific and enabled many new research activities, which were finished later. The MIPITS system developed for the study course "Fundamentals of artificial intelligence" was realised according to the novel intelligent tutoring system development methodology MASITS (Lavendelis, 2009). The student model for the IKAS, which uses the conception and architecture of multiagent based user modelling shell AGENT-UM, is

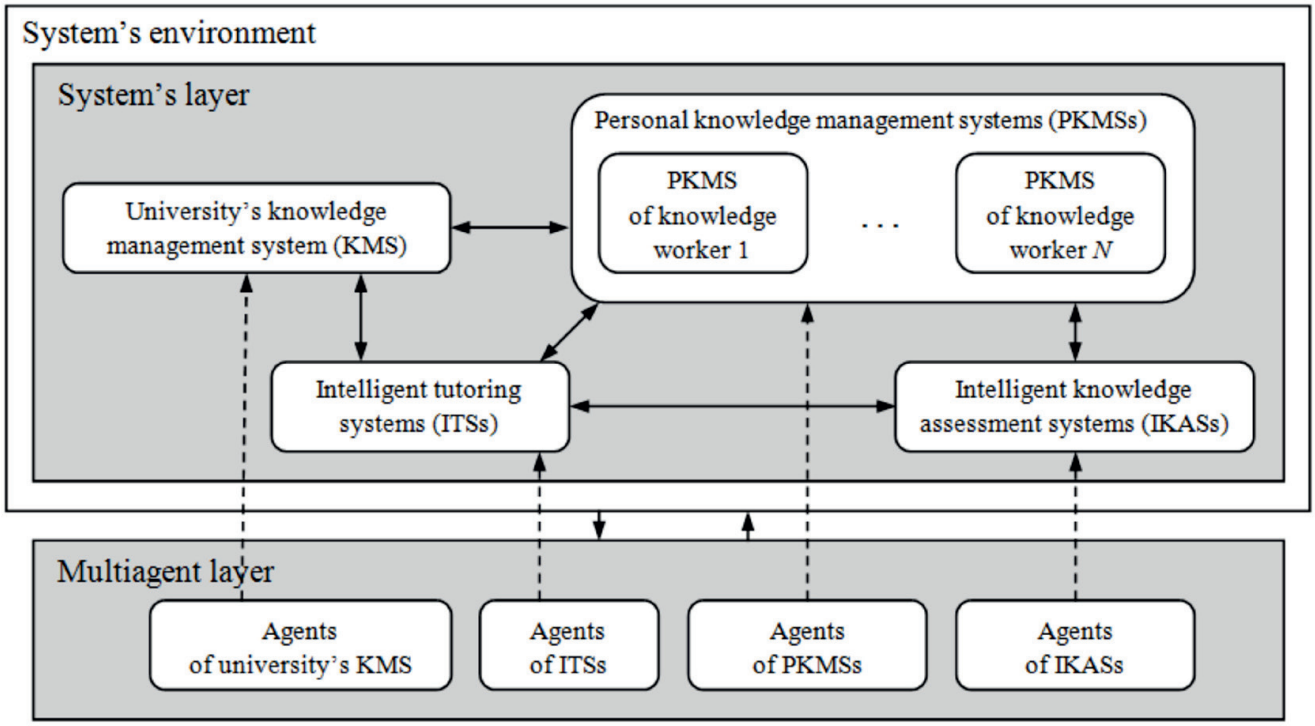

Figure 3. Two layers of conceptual framework.

worked out by R. Lukashenko (2012). Research on extension of the usage of ontologies in the IKAS started with development of the algorithm of OWL ontology transformation into a concept map. In addition, the algorithm for transformation of concept maps into OWL ontology, the algorithm for supporting a teacher in learning material authoring based on the idea that learning objects are not isolated concepts but correspond to subgraphs of concept map, and the algorithm for a study course and a personalised learning path compilation were created. The corresponding tools were implemented with the purpose to integrate them with the IKAS, as well as the tool MergeUtil for handling files with merged ontologies (the purpose of ontology merging is possibility to check are topics and/or study courses connected or not) was developed (Graudiņa, 2011). Overall, five doctoral degrees were received on topics of intelligent tutoring systems (in addition to three abovementioned, there is also A. Anohina's (2007) initial work on the IKAS conceptions, and research by K. Osis (2011) on personal knowledge management systems for learning based on mobile devices). Those are only few telling examples of rather broad research in AI, but they together with other results not mentioned here paved the way to subsequent works.

The experience and acquired knowledge allowed to submit a new scientific project of Latvian Council of Science: "Methods and models based on distributed artificial intelligence and web technologies for development of intelligent applied software and computer system architecture" (2009–2012). This was the project where research directions of five professors of the Institute of Applied Computer Systems were joined. The objective of the project was to develop the novel approach, methods and models for development of intelligent applied computer systems and their architectures. The tasks of the researchers' group conducted by the author were connected with development of the conceptual model of open multiagent system's architecture and its design methodology. The successfully completed project and achieved results were basis for the new project: "Development of models and methods based on distributed artificial intelligence, knowledge

management and advanced web technologies for applied intelligent software" (2013–2016). As this project is of the same character as the previous one, only the part of it will be done by the research group conducted by the author. The task (together with other groups) is to develop the framework for applied intelligent software based on distributed AI and Web technologies. Since 2010, the research group conducted by the author is also involved in the project "Advanced information technologies and their applications based on ontology and model transformations", which is realised within the framework of the research programme of state significance IMIS. Two objectives of the project were formulated:

1) to develop mutual transformations of problem domain specific ontologies and models of knowledge structures (cognitive structures), transformation support tool and methods of comparison of models of knowledge structures;
2) to develop the framework based on distributed AI and Web technologies using Web services, ontologies and intelligent agent components.

The research of the group is focused on the following topics:

- transformations of ontologies and concept maps;
- comparison and assessment of concept maps;
- knowledge models used in structural modelling;
- development of mechanisms for interaction of intelligent agents and Web services;
- architecture of agent based knowledge service platform's prototype for tutoring systems.

In this project, in fact, the research group step by step will move towards Semantic Web conceptions and applications.

So, from the given above description one can conclude that the DSTD has been very active in AI research during decades, in particular, in directions of knowledge acquisition, representation and processing (reasoning), as well as development of intelligent agents and multiagent systems for tutoring and knowledge assessment. Besides, concurrently with described research activities, just after the defence of his thesis, associated professor A. Ņikitenko started research in robotics, namely, development of autonomous robotic platforms. Soon he came to the conclusion that there are a lot of solutions for individual robots while research of robotic systems is underdeveloped. As it turned out, the software of multirobotic systems can be based on multiagent paradigm, and this is the topic on which research interests of representatives from both directions (multiagent systems and robotics) joined. Yet more, this is the problem domain where research interests of researchers from RTU and from LLU met.

Collaboration between RTU and LLU

The Faculty of Computer Science and Information Technology of RTU and the Faculty of Information Technologies of LLU stay in close contacts for more than a decade. The collaboration is going on in two dimensions – the study process and research. Contacts between both faculties first started concerning study programmes. In early years of 21st century when the Faculty of Information Technologies started to develop its study programmes "Computer control and computer science" (academic bachelor studies) and "Programming" (vocational bachelor studies) as well as "Information technologies" (academic master studies), the study programmes of the Faculty of Computer Science and Information Technology ("Automation and computer engineering", "Computer systems" and "Information technology" which were developed at RTU in the middle of the 1990s) served as prototypes.

Abovementioned study programmes of LLU have very good quality, because, as a rule, marks with which bachelor and master theses of students are assessed by the State examination commissions (the author serves as the chairman right from the start of graduation from the study programmes "Computer control and computer science" and "Information technologies") are high. Collaboration between both faculties continues; it was more intensive when in 2006 the European Structural Funds project "Modernisation of LLU study programme "Information technologies"" was commenced. Ten professors and associated professors of the Faculty of Computer Science and Information Technology worked as experts to develop the advanced study courses for the masters study programme. They also taught their courses during one study year. The author has developed and taught the course "Systems theory and control". Teachers from RTU also worked as guest lecturers at LLU for years.

Nowadays, the Faculty of Information Technologies of LLU is a mature higher education institution having its own doctorate council, where first doctoral theses have already been successfully defended (the author is the member of this council and was the reviewer of two doctoral theses).

However, frankly speaking, the abovementioned contacts are prevailing at individual level. Contrary, research activities are carried out by groups of researchers from both faculties. Very close coordination of research activities started in October 2010 within the framework of European Regional Development Fund project "Development of technology for intelligent multiagent robotic system". The submitter of the project is RTU, and collaboration partners are LLU and Terra Virtuala. The general goal of the project is to increase work efficiency and reduce negative impact on environment in biological agriculture by development of intelligent multiagent robotic system technology. The specific objective is to use advantages of integration of multiagent systems and robotic platforms to achieve the general goal. The foreseen result of the project is the novel technology which allows using relatively simple and cheap robots to perform one shared task. From the structural point of view, the project includes three parts:

1) software based on intelligent agent paradigm;
2) hardware – a robot team (iRobot robots ROOMBA are supplied by Terra Virtuala);
3) evaluation of environment influence on performance of robot team.

During the work on the project, researchers have many challenges originated from AI and agriculture fields. The flavour of tasks to be solved may be grasped from examples of problems (due to the scope of the paper not all are mentioned). Software developers must answer the following questions:

- how to decompose the complex problem, split up tasks between agents, and combine partial solutions?
- how to choose and implement the appropriate architecture of multiagent system?
- how to develop effective planning and learning algorithms?
- how to provide communication of agents?
- how to provide agents with ability to form a team or a coalition?
- how to provide reliable and safe operation of a heterogeneous multiagent system?
- Hardware developers face the questions:
- how to provide ability for each robot to orient itself in space?
- which additional sensors are needed to perceive all necessary information about an environment for performance of a specific task?
- how to reduce uncertainty caused by processing of sensor data?

- what kind of communication and electrotechnical infrastructure must be implemented to provide effective operation of system?
- Researchers from LLU must find answers to questions such as:
- how aggressive environment, for example, existing in greenhouses will influence the system's performance of a specific tasks?
- which are shortcomings of existing robotic technologies that prevent their wide usage in agriculture?
- which factors and parameters of environment influence applications of robots in agriculture?

The software developers' group is conducted by the author, the hardware developers' group – by associated professor A. Ņikitenko (some electronic parts have been developed by researchers from LLU), and all environmental problems must be solved by researchers from LLU. At the moment, the project successfully draws to a close, and productive collaboration between researchers from both faculties is the promising base for future joint projects.

Conclusions

The paper was written at the time when during 2012 and 2013 two universities – RTU and LLU – celebrate their 150th anniversaries. The purpose of the author was to describe the short history of his research field – artificial intelligence in total and AI research activities at the DSTD, in particular, as well as to show how this field enables good cooperation between IT faculties of both universities. Successful fulfilment of the joint research project confirms that in future such cooperation has very good perspectives because each group perfects one's knowledge. Expertise of researchers from RTU in development of multiagent systems and autonomous robots supplemented with knowledge of researchers from LLU in agriculture opens new perspectives. We see a large potential to service robotics in near future not only in such directions as large area maintenance, domestic service, education, elderly people assistance and security, but also in agricultural robot systems. In agriculture, robot teams can harvest, for example, pick berries or gather tomatoes or cucumbers. Besides, robots may be helpful also in so called precise agriculture, for instance, to give needed proportions of fertilizers or water for plants. So let's be sure that our collaboration in future will give new innovative solutions for national economy.

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Scientific Activity of the Economists

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Abstract. Since the year 2000, the leading scientists of the Faculty of Economics (FE) have conducted research in the following programmes: "Assessment of Risk Factors and Risk Management in Agriculture in Latvia" and "Risk and Crisis Management Systems in Agriculture in Latvia". These research results were summarised in two scientific monographs that were produced under the guidance of the Faculty's scientists. In 2012, the academic staff published their research on the use of renewable energy, the effects of protectionism instruments, solutions to tax problems, and the development of the agricultural sector in four monographs. The diversity of scientific activities performed by the FE is characterised by a broad and diverse scope of topics of doctoral dissertations. The academic staff not only supervise the elaboration of dissertations, but also work on scientific topics themselves. Contemporary topics, which relate to the role of social capital in rural development, are also researched. Comprehensive research on biomass as well as the use of manure and production waste in generating renewable energy is conducted. The scientists and doctoral students of the Departments of the FE also work on other urgent topics in macroeconomics, microeconomics, regional development, finance and credit, marketing, and other fields.
Key words: Economy, science, doctoral students, projects, development.

Introduction

Since 2000, the scientific activity of the academic staff of the Faculty of Economics (FE) has been associated with tackling economic problems after joining the European Union.

The research conducted required competences not only in economics, but also in management, as management and governance problems were and are the most urgent. Besides, research competences are needed not only in the primary sector, but also in the secondary sector – in the manufacturing industry processing agricultural and forest products. The more than 10-year period of analysis in the research activity of management specialists thematically includes several fields.

The scientific activity of the staff of the FE may be relatively classified into two macro-directions according to the scope of work of the Departments:

1) entrepreneurship and management;
2) agricultural and regional economics.

Entrepreneurship and management

Since 2002, Latvia University of Agriculture (LLU) has worked on agricultural risk and crisis management systems within the research programme "Assessment of Risk Factors and Risk Management in Agriculture in Latvia", financed by the Latvian Council of Science (LCS). The Faculty's leading scientists and also doctoral students engaged in this programme with a sub-project "Examination of the Economic Possibilities and Threats of Risks and the Assessment of

Risk Effects" (supervised by FE prof. Kazimirs Špoģis); in the second stage of the programme, the economists worked on the sub-programme "Examination of the Economic Threats of Risks and Crises in Primary and Secondary Sectors and the Assessment of their Effects".

The research findings are already published in two scientific monographs and in many research papers in scientific periodicals.

In the first monograph, research findings of the Faculty's economists are included in Chapter 8 (pages 385–657) (authors: V. Buģina, A. Dobele, A. Graudiņa, I. Jakušonoka, L. Siliņa, I. Jurgena, J. Kaktiņš, L. Mihejeva, A. Radžele-Šulce, K. Špoģis, A. Vilciņa, and A. Zvaigzne), while in cooperation with other researchers, the economists co-authored also Chapter 1 and Subchapters 4.3 and 6.5. The share of work performed by the economists comprises almost a half in this monograph. Its compiler was FE prof. K. Špoģis. The main research fields of the economists are presented in Chapter 8 "Economic Possibilities or Threats of Risks and the Assessment of Risk Effects", in which particular research findings are subdivided into eight subchapters. The research findings are grouped into several fields.

Research on quality risk management at agricultural enterprises and on farms has become a special priority in riskology, as the effects of unskilful, unprofessional, incompetent, careless, or faulty management become increasingly apparent in economic performance.

Intellectual, social, economic, and dispositive risks were especially researched, classifying them and assessing indicators for opportunities and threats.

The second priority is economic assessments of natural risks in Latvia's regions, thus identifying possibilities for reducing the negative effects of uncontrollable risks and maximising the potential gains in the regions of Kurzeme and Zemgale.

A broad research direction in risk control and management in private forestry has been started and is still being continued. An important research direction is the research on finances, loans, and insurance.

Research on risks in the rural tourism industry has been started.

Research in the commenced directions in riskology continued, and the research findings were presented in the second scientific monograph "Agricultural and Food Risk Management" (2007); its compiler and scientific editor was FE prof. K.Špoģis, and co-authors were the following FE academics: I. Jakušonoka, J. Kaktiņš, L. Mihejeva, A. Radžele-Šulce, L. Švānberga, S. Rivža, L. Ruža, L. Siliņa, K. Špoģis, and R. Šulca.

In this period, the main attention was paid to management risks at agricultural enterprises, especially to strategies of owners and managers of agricultural enterprises, as well as to specialisation and production concentration problems. The essential and consequent effects of production concentration on quality management and its impacts on higher yields and productivity were proved.

A strategy of managers (owners) of farms in managing long-term investments, in its turn, determines, to a great extent, the efficiency of the structure of enterprises. These findings contributed to the research on risk management opportunities at higher management levels, which was commenced earlier.

Diversification of various agricultural industries, sub-industries, auxiliary industries, and kinds of activity became topical with Latvia's integration in the European Union, as the amounts of agricultural output that were allowed to be produced in Latvia within the common European market were outlined. It became clear that some area of agricultural land and other resources would be unutilised.

Diversification problems became more acute after joining the European Union when structural funds intended for financial support for rural areas were distributed: Inadequately small structural funds were allocated to Latvia's farmers and rural areas – only 17% of the total amount, which considerably reduced the competitiveness of agricultural goods in the common European market. Farms stopped producing agricultural products and commodities for the market, agricultural land was rented out or sold, and the concentration of land resources and the industrialisation of agricultural production took place. Agricultural land was increasingly exploited for other – non-agricultural – purposes: solar energy accumulation in plant biomass and its use as an energy source.

The diversification problems require adequate and new solutions that are based on the principles of economics and management.

The scientists of the FE focussed on these problems already several years ago. By participating in research project tenders held by the LCS, the first project "Diversification of Agriculture in Latvia with Integration in the European Union" was won and commenced in 2001 (V. Strīķis, K. Špoģis, and others). Within this project, agricultural economic problems, which arose owing to the land reform and could be predicted with the integration in the common European market, were tackled in Latvia.

The second project – "New Opportunities and Problem Solutions for Rural Diversification in Latvia under the European Union" (manager Kazimirs Špoģis) – already focused on new problems that were caused by the conditions determined by the common European market and EU's financial support (the Structural Funds), as these conditions contributed to excluding some agricultural area from the production of food and agricultural commodities.

In 2009, the third project or diversification research stage "Structural Changes, Transformation and Diversification, Factors, Effects, and Visions in Agriculture" (manager prof. K. Špoģis) was commenced, and doctoral and master students were engaged in this project.

Agricultural and regional economics

Over the recent years, the Faculty's academic staff actively participated in national and international projects both as managers and as participants, thus gaining valuable experiences that may be used in their main occupation – the education of a new generation in the fields of economics and management. The key individuals are named in this chapter. Under the guidance of the Faculty's professor and academician Baiba Rivža, research is conducted on:

1) use of micro-loans in rural social and economic development;
2) use of the principles and methods of mentoring in the formation of a knowledge society;
3) "The Application of the Network of Foresight Specialists Supporting Rural Policy, the Improvement of the Database of Agricultural Scientific Research and Equipment and the Provision of Presidency of the Association of European Academies of Agriculture, Food and Natural Sciences".

Under the guidance of professor Voldemārs Strīķis, several projects of research on social capital were implemented (in cooperation with M. Pelše, S. Ancāns, J. Leikučs, E. Igaune, D. Vīksne, and A. Vītiņa).

Prof. Vulfs Kozlinskis managed an international project – EEA/Norwegian Project LV0040 "Developing and Delivering Innovative Training Modules for Baltic Executives Using an

Interdisciplinary Approach to Entrepreneurship and Advanced Technologies" and the national level project "Effects of Differentiated Value-added Tax Rates for Certain Groups of Food on the Consumption of these Products and the Competitiveness of Producers of these Products".

Prof. Irina Pilvere manages the following large projects:

1) "Assessment of the Administrative Burden and Costs for Framers" as well as "Assessment of the Administrative Burden and Costs in the Legal Regulation of Food Safety" (in cooperation with V. Kozlinskis, A. Dobele, V. Tetere, and others);
2) "Ex-ante Assessment of the Rural Development Programme of Latvia 2007–2013" and "Ex-post Assessment of the SAPARD Programme for Agricultural and Rural Development in Latvia" (in cooperation with V. Kozlinskis, I. Jakušonoka, R. Šulca, and others);
3) "European Union Funds and their Funding for Developing the National Economy of Latvia" (in cooperation with Z. Buldenberga, V. Tetere, I. Upīte, and others).

Prof. Veronika Buģina managed the following projects:

1) "Development of Cooperation in Agriculture in Latvia under EU Conditions" (in cooperation with J. Kaktiņš and K. Polačenko);
2) "Methodology for Assessing Natural Resources in Vidzeme Region within the Environmental Sustainability Context" (in cooperation with I. Pučure).

Prof. Anastasija Vilciņa managed the project "Resources of Bread Producing Enterprises and their Effect on the Development of this Industry".

Prof. Ingrīda Jakušonoka managed the project "Possibilities for Developing and Financing Small Enterprises in Rural Areas in Latvia" (the academic staff involved: I. Kantiķe, A. Svarinska, V. Raņķevica, A. Zvaigzne, and A. Eglīte).

Prof. Īrija Vītola managed the project "Improvement of the Tax System in Latvia to Ensure Economic Development and Social Justice", financed by the LCS (in cooperation with I. Jakušonoka and I. Leibus).

Assoc. prof. Aija Eglīte is the national manager in the six-country project "CHANCE-Community Health Management to Enhance Behaviour".

Assoc. prof. Modrīte Pelše managed the project "Assessment of the Economic Performance and Profitability of a Biogas Facility" (the academic staff engaged: V. Strīķis, K. Naglis-Liepa, and J. Leikučs).

Over the period of analysis, the academic staff of the FE actively engaged as participants in other projects as well.

The academic staff continued managing the commenced projects or started new scientific projects. The total number of projects reached twenty. The Ministry of Education and Science started allocating funds for universities for the implementation of scientific projects. In this way, funds were allocated for implementing four LLU scientific projects on economic topics. Prof. P. Rivža managed research on the research and training farm "Vecauce" to start the operation of a biogas facility, prof. I. Pilvere analysed the effects of European Union funding on rural development in Latvia, prof. V. Strīķis continued his research on the role of building social capital in rural enterprises, and prof. V. Buģina conducted research on the association of the use of natural resources with the environment. The LCS projects were continued: prof. K. Špoģis researched rural diversification possibilities and together with prof. P. Rivža continued managing research on agricultural risk problems, but prof. B. Rivža managed the establishment of a mentoring movement in Latvia.

The research findings were actively published in publications recognised by the LCS, as well as more than 20 books, methodological materials, and research papers were produced. V. Strīķis compiled a book entitled "LLU Faculty of Economics". In 2008, the deceased professor B. Treijs award was instituted, which was awarded to assoc. prof. M. Pelše for her doctoral dissertation "Social Capital Development Possibilities in Zemgale Region" (scientific supervisor V. Strīķis).

Several conferences were held, traditionally the central one was the international scientific conference "Economic Science for Rural Development", which would be held for the fourteenth time in 2013, and 32 volumes of conference proceedings were published, which were placed in international scientific databases.

The number of completed projects increased – totally, 30 projects in 2009. The projects were mostly managed by I. Pilvere, B. Rivža, K. Špoģis, and others.

As regards publications, one may emphasise the books written and published by A. Kalniņš: "Biofuels" and "Economic and Environmental Gains from Biogas Production". A large number of research papers and reports were presented at international conferences.

In 2009, a research cycle ended for eight doctoral students who defended their dissertations. This number was considerably greater than in the previous years.

In 2009, the professor B. Treijs award was awarded to Inta Slavinska for her doctoral dissertation "Logistics in Regional Development" (scientific supervisor K. Špoģis).

In 2010, scientific activities were continued; yet, one has to note that the Ministry of Education and Science stopped granting funds for research to universities, therefore the implementation of projects slightly declined. The scientific activity mostly focussed on supervising doctoral students who were granted European Social Fund (ESF) funding. The ESF project "Attraction of Human Resources to the Research of the Renewable Energy Sources" was started; scientific manager P. Rivža, researchers: A. Kalniņš, V. Strīķis, M. Pelše, and others.

Among the many publications, there are such books as "Economic Assessment of Agricultural Energy Crops" by V. Strīķis (compiler), A. Kalniņš, and others, and the bibliography "Latvian Academy of Science Academician Baiba Rivža".

In 2010, owing to ESF doctoral scholarships, a record large number of doctoral students completed their scientific studies, namely, a doctor's degree in economics was conferred to nine individuals; of them, four were supervised by prof. B. Rivža, one by professors I. Jakušonoka, I. Pilvere, and V. Strīķis, and by assoc. prof. A. Eglīte. The professor of the year B. Treijs award was awarded to a new scientist, Ligita Bite, for her doctoral dissertation "The Quality of Labour Environment and its Management in Enterprises of Latvian Regions" (scientific supervisor L. Mihejeva).

In 2011, the Faculty's academic staff continued their activity in their traditional fields. Forty eight reports were presented at international conferences, and 39 reports – at conferences in Latvia. Fifty two papers were published on topical economic issues. Eight doctoral students successfully completed their dissertations, which resulted in conferring a doctor's degree in economics to their authors. The professor B. Treijs award was awarded to R. Šulca for her doctoral dissertation "Development Possibilities for the Latvian Local Governments' Internal Audit System" (scientific supervisor I. Jakušonoka), and to I. Upīte for her doctoral dissertation "Use of Investment Support in Latvian Agriculture" (scientific supervisor I. Pilvere). International activities were specific to that year.

Since 2012, the Faculty has commemorated former professor Ervids Grinovskis by holding discussion seminars on topical economic issues. A book entitled "Professor Ervids Grinovskis" is prepared. The participants of a seminar proposed to write a declaration advocating an idea that farmers of the Baltic States have to receive fair EU direct payments which should be equal to the average size of EU support payments if measured per ha of land. In February 2012, the declaration was discussed at a meeting of scientists, and it was signed by the rectors of agricultural universities and the presidents of academies of science of Latvia, Estonia, and Lithuania, including president of the Latvian Academy of Agricultural and Forest Sciences Baiba Rivža and other leading scientists. The declaration was sent to Brussels to EU agricultural commissioner D. Ciolos.

The year 2012 was characterised by the book "LLU Professor Kazimirs Špoģis" published in this year. The professor's family instituted a scholarship of honour for new scientists to keep the memory about the professor. The first awardees of this scholarship were the former doctoral students of K. Špoģis: Dina Popluga and Agnese Radžele-Šulce. The Faculty of Economics, in its turn, furnished room 310 in memory of professor Kazimirs Špoģis.

In 2012, the academic staff published their research on the use of renewable energy, the effects of protectionism instruments, solutions to tax problems, and agricultural development in four monographs.

Conclusions

The active engagement of the Faculty's leading scientists and a few doctoral students in the research programme on riskology and in writing and publishing two unique scientific monographs may be regarded as an important period.

Agricultural and rural diversification, affected by the European Union Common Agricultural Policy and globalisation processes, is an especially urgent and long-term research topic.

The Faculty's scientists manage and are involved in both international and national research projects. The main sources of financing projects are the EU-funded programmes – the European Economic Area/Norwegian Financial Mechanism – as well as funding provided by the Latvian Council of Science, the Ministry of Agriculture, and the Ministry of Education and Science.

At the end of 2012, four monographs on the use of renewable energy, the effects of protectionism instruments, solutions to tax problems, and agricultural development were published.

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Review on Scientific Work at the Faculty of Social Sciences, 2001–2013
Pārskats par zinātnisko darbu Sociālo zinātņu fakultātē, 2001–2013

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Abstract. The Faculty of Social Sciences has been established at the Latvia University of Agriculture in 2001. The Faculty has three departments: the Department of Sociology, the Department of Philosophy, and the Department of Languages. The Department of Sociology has defined three main areas for the research: 1) public administration and sociology of organisations, including the issues of communication, public management in higher education, and cooperation between local governments of Latvia; 2) social inclusion and exclusion, including aspects of social work, family friendly jobs, social psychology, life quality of senior citizens; and 3) regional and rural development, including the problems of labour market, problems of women, research on small towns, and development of tourism. The scientific priorities of the Department of Philosophy are: 1) research in the branches of philosophy – philosophy of science, philosophy of education, bioethics, philosophy of religion; 2) philosophical problems of human personality and culture; 3) studies of Latvian philosophical thought. The priorities of the scientific activities of the Department of Languages are: 1) life–long education; 2) professional foreign language teaching/learning; 3) internationalization of the study process; 4) development of professional competence. The main criteria by which the Faculty's scientific work can be assessed are published scientific papers and monographs, doctoral dissertations, participation in scientific research projects, organizing methodological seminars, international collaboration, and contributions to scientific conferences. The faculty is organizing annual international scientific conferences "New Dimensions in the Development of Society".

Kopsavilkums. Latvijas Lauksaimniecības universitātes Sociālo zinātņu fakultāte tika nodibināta 2001. gadā. Fakultātē ir trīs katedras: Socioloģijas katedra, Filozofijas katedra un Valodu katedra. Socioloģijas katedra ir definējusi trīs galvenos pētniecības virzienus: 1) publiskā administrācija un organizāciju socioloģija, ieskaitot komunikācijas problēmas, publisko menedžmentu augstākajā izglītībā un sadarbību starp Latvijas pašvaldībām; 2) sociālā iekļaušana un izslēgšana, ieskaitot sociālā darba aspektus, ģimenēm draudzīgu darba vidi, sociālo psiholoģiju, pensionāru dzīves kvalitāti; un 3) reģionālā un lauku attīstība, ieskaitot darba tirgus problēmas, sieviešu problēmas, mazo pilsētu pētījumus un tūrisma attīstību. Filozofijas katedras pētījumu prioritātes ir: 1) pētījumi filozofijas nozarēs – zinātnes filozofijā, izglītības filozofijā, bioētikā, reliģijas filozofijā; 2) cilvēka personības un kultūras filozofiskās problēmas; un 3) pētījumi Latvijas filozofiskajā domā. Valodu katedras zinātniskā darba prioritātes ir: 1) mūžizglītība; 2) profesionālās svešvalodas mācīšana; 3) studiju procesa internacionalizācija; un 4) profesionālās kompetences attīstība. Nozīmīgākie kritēriji, pēc kuriem var vērtēt fakultātes zinātnisko darbu, ir publicētie zinātniskie raksti un monogrāfijas, doktora disertācijas, dalība

zinātniski pētnieciskos projektos, metodoloģisko semināru organizēšana, starptautiskā sadarbība un dalība zinātniskās konferencēs. Fakultāte organizē gadskārtēju starptautisko zinātnisko konferenci "Jaunas dimensijas sabiedrības attīstībā".

Key words: Latvia University of Agriculture, Faculty of Social Sciences.

Introduction

The Faculty of Social Sciences has been established at the Latvia University of Agriculture in 2001 on the basis of previous Institute of Humanities. The Faculty has three departments: the Department of Sociology, the Department of Philosophy, and the Department of Languages.

The main criteria by which the Faculty's scientific work can be assessed are published monographs and scientific papers, doctoral dissertations, participation in scientific research projects, international collaboration, and contributions to scientific conferences. Annual international scientific conferences "New Dimensions in the Development of Society" are organized by the Faculty since 2002. This conference has become a traditional scientific event for the Faculty's staff and students, as well as for researchers from Bulgaria, Belarus, Czech Republic, Estonia, Finland, Germany, Great Britain, Italy, Lithuania, Poland, Russia, Slovakia, and other countries.

The Faculty has established cooperation with Lithuanian University of Agriculture (Kaunas, Lithuania), Higher School of Informatics and Economics of Olsztyn Society of General Studies (Poland), and University of Warmia and Mazury in Olsztyn (Poland).

The main areas of research

Scientific activities of researchers of the Faculty are aimed at the study of social phenomena which are topical in social life at the moment and have some impact on the higher education as well. Some researchers have been carrying out the research in accordance with their own scientific interests. Nevertheless, it is possible to define the main directions of the research carried out by the Faculty members.

The **Department of Sociology** has defined three main areas for the research:

1) public administration and sociology of organisations;
2) social inclusion and exclusion;
3) regional and rural development.

The scientific priorities of the **Department of Philosophy** are the following:

1) research in the branches of philosophy: philosophy of science, philosophy of education, bioethics, philosophy of religion;
2) philosophical problems of human personality and culture;
3) studies of Latvian philosophical thought.

The priorities of the scientific activities of the **Department of Languages** are:

1) life-long education;
2) professional foreign language teaching/learning;
3) internationalization of the study process;
4) development of professional competence.

Public administration, and sociology of organisations

Social changes and society's transformation have a great impact on social processes in regions and therefore the staff of the Department of Sociology paid attention to application of scientific knowledge and elaboration of innovative solutions.

Objective rules as being essential in the field of public management which should be taken into account in organisational management are discussed by associated professors of the Department of Sociology Jānis Ābele and Voldemārs Bariss in their books on public administration "Strategic Management" (2006) and "Organizations" (2008). The authors point out that "all can be regarded from the organisation theory point of view, for example, state institutions, labour environment, family, etc." (Ābele, Bariss, 2008, p. 3).

The high level of application competence of innovative knowledge in the field of societal organisations means better communication. Practical advice in the application of contemporary social psychology, language, culture and art of rhetoric has been elaborated by V. Bariss. He has published the book "Applied Public Speech" (Bariss, 2008).

Innovations in public management and innovative public management processes in the state institutions of higher education have become the object of Dita Štefenhāgena's PhD research. The topic of Dina Bite's Doctoral thesis is the research on the cooperation between the local governments of Latvia, assuming that the cooperation is an essential instrument for the facilitation of regional development.

Social inclusion and exclusion

To promote the quality of the social environment in order to develop communication for the establishment of social contacts and partnership with social institutions and public organisations is one of several issues of research performed by the researchers of the Department of Sociology. The research on the social inclusion and exclusion situation in Jelgava city was carried out under the guidance of professor Aija Zobena, associated professors Voldemārs Bariss, Jānis Ābele, Jānis Ķusis, assistant professors Maiga Krūzmētra and Signe Dobelniece as well as by Valda Kronberga, Līga Rasnača, Laima Barisa, Līga Paula, Ginta Kronberga, Ieva Liepiņa, Dina Bite and Lana Janmere with the assistance of the staff of Jelgava city government.

Consequently, the plan for further social development was elaborated as the programming document to receive the EU SF financing for 2004–2006. The strategy for the activities of the government of Latvia and the priorities for investment of the EU structural funds were elaborated. The results of the research provided the basis for the document according to which financing was assigned and which was unilaterally adopted in the European Commission. The EU financed activities became a substantial landmark for the elaboration of the plan. Researchers developed the substantiation for the further development of projects of corresponding institutions of self-governments for the time period 2004–2010 to eliminate social alienation. The research was elaborated within the framework of the cooperation programme of the Baltic Sea Region 2001 financial support.

In 2008, two dissertations were completed in the Department of Sociology concerning social inclusion and exclusion: by Larisa Brokāne on social psychology, and by Signe Dobelniece on social work. Viola Korpa, being a doctoral student of the Latvia University, carried out the research on the harmonization of the family life and work planning, focusing on family friendly

jobs. Jolanta Millere performed the research on the life quality in families with children having special needs. The topic of Anda Grinfelde's Doctoral thesis in economics was the life quality of senior citizens in various regions of Latvia.

To cover several aspects of social inclusion and exclusion, S. Dobelniece, V. Korpa and Evija Caune (lecturer of the Departments Philosophy) are working on the joint grant project of the Latvian Council of Science "Formation of the Family Friendly Work Environment in Latvia: from the Point of View of Business Organizations".

Regional and rural development

The necessity to pay more attention to regional and rural development has captured the researchers' interest. The staff of the Department of Sociology focuses on the research of treating employment problem in rural areas and regions of Latvia. The EU project "Specific Problems of the Labor Market of Latvia and its Regions" was elaborated in cooperation with six universities of Latvia under the guidance of assoc. prof. V. Bariss.

Problems of women in rural areas, their readiness and possibilities to form businesses are researched by assist. prof. Maiga Krūzmētra. The problems of local governments are researched by Valda Kronberga and Laima Barisa.

The purpose of the research was to promote social partnership, to restructure institutions and organisations in order to empower them, to provide assistance, to design models of development, and so on. At present, nine former doctoral students of the Department of Sociology are working on or have defended their doctoral theses, five of them in the field of regional and rural development: Līga Rasnača on unemployment problems and their treatment in small towns, Līga Paula on partnership as social innovation for rural development, Ženija Krūzmētra on the restructuring of the society in small towns, Dina Bite on models of regional development, and Dace Kaufmane on tourism systems' models in different regions of Latvia.

The problems of education and environmental issues in municipalities are being researched by L. Barisa and V. Kronberga. The doctoral theses of D. Kaufmane, Z. Krūzmētra and L. Rasnača have been devoted to regional problems of population, tourism and labor market. The group of researchers under the guidance of assoc. prof. Jānis Ķusis has researched the sustainable development of small towns since 2006. The main objective of the research is to evaluate how municipalities use new possibilities created by the administrative territorial reform to become centres of employment and services.

The role of regional universities in economic and social development was discussed by D. Bite, G. Kronberga and L. Paula in cooperation with other universities of Latvia in the project financed by Norwegian grant program "Universities in their Regions: Interaction of Knowledge and Practice" (2011).

Research in the branches of philosophy – philosophy of science, philosophy of education, bioethics, philosophy of religion

Although the Department of Philosophy is not among the largest departments in the structure of the Latvia University of Agriculture (nine faculty members in 2012), its role has been significant, sustaining the intellectual background of students, organizing seminars about topical scientific and philosophical issues, participating in mass media discussions, and carrying out research in various branches of humanities.

Assistant professors Kārlis Lūsis and Leonards Leikums, and associated professor Gunārs Brāzma have developed methodology for teaching philosophy of science course (for master students), including history, epistemology and ethics of science. As a result of this research, the book "Philosophy of Science" has been published (Brāzma, Leikuma, Leikums, Lūsis, Moskvins, 2011). Lecturer of the Department Ināra Leikuma has also participated, looking at the psychological aspects of scientific work.

L. Leikums and G. Brāzma are doing research concerning the role of philosophy in the contemporary society and education (Leikums, Brāzma, 2012). The research in philosophy of education, particularly concerning the role of higher education in the context of the European Union, has been carried out by lecturer Evija Caune. The research concerning the development of education in Latvia has been carried out by lecturer Anna Rāta.

G. Brāzma is doing research in bioethics and philosophy of biology, particularly in philosophical problems of evolutionary biology (Brāzma, 2009). His PhD thesis "Bioethical Aspects of the Creation and Termination of Human Life" has been the basis for the monograph (Brāzma, 2010). Chapters of the monograph analyses topical bioethical issues, such as the moral status of human embryo, abortion, *in vitro* fertilization, genetic enhancement, cloning, and euthanasia.

Juris Vuguls is doing research in philosophical and historical aspects of the world's religions, carried out mainly by hermeneutical and dialogical methods (Vuguls, 2012). The topic of his PhD thesis, defended in 2012, was "Ideas of Orthodoxy and Hesyhasm in Latvia 1836–1934". Philosophy of religion has also been the subject of the research by Ignats Trepšs (lecturer of the Department until 2008).

Academic staff of the Department (E. Apsīte, G. Brāzma, E. Caune, I. Leikuma, L. Leikums, K. Lūsis, S. Poča, J. Vuguls) has published the textbook "Practical Philosophy" (2008), prepared in the framework of the research project by the Ministry of Education and Science. The authors of the book's chapters interpret the topics related to philosophy of science, ethics, world religions, philosophy of history, social philosophy, philosophy of education, the problems of personal values, and the issues of postmodernism.

Philosophical problems of human personality and culture

The academic staff of the Department has been developing research on the problems of human personality and culture both theoretically and practically. E. Caune, an expert on gender issues, has participated in the research concerning gender equality. I. Leikuma's research is focused on the topic of Latvian identity in the context of historical development.

Professor Aloizs Strods (1924–2008) carried out the research on philosophy of personalism and alienation. History and theories of culture has been the topic of research by Zinaīda Andersone (lecturer of the Department until 2006).

Studies of Latvian philosophical thought

K. Lūsis is the author of papers and prefaces of books on the history of ideas in Latvia during the eighteenth and nineteenth centuries, including the New Latvians movement and its member Krišjānis Valdemārs.

I. Leikuma has studied approaches to the problem of consciousness in the history of Latvian philosophical thought (Leikuma, 2002), and the ideas of Latvian scholar Pēteris Birkerts.

Several members of academic staff (A. Strods, I. Trepšs, L. Leikums, S. Poča) have studied Latgale's (Eastern Latvia's) history of philosophical thought and the contemporary problems of Latgale's culture. I. Trepšs has organized scientific conferences dedicated to Latgalian scholars Konstantīns Raudive (1999) and Norberts Trepšs (2003), as well as the conference dedicated to the distinguished Latvian philosopher, member of E. Husserl's phenomenological movement Teodors Celms (2007).

Life-long education

The processes in higher education system were highlighted from the university instructors' point of view by S. Bremze and J. Hobrough in the research "Changes in the Lifelong Education of a Lecturer" (Bremze, Hobrough, 2007). The academic staff of the Department of Languages, associate professors S. Bremze and D. Grasmane, assisted in the maintenance of the international scientific projects "Changes in Higher Education in an Expanding Europe" (Surrey University, Great Britain), "Food Choice and Eating Habits" (Roehampton University, Great Britain), "Latvia on its Way to EU" (Latvia, Germany, UK, the Netherlands, Finland, USA, Lithuania).

To stress the importance of the role of the Latvian language as the state language, the role of its history and development in the history of the development of the Latvian state, in 2007, the Department of Languages arranged the conference of the Latvia State Language Commission "State Language: Semantic Aspect". Presentations were also made by the lecturers of the Department of Languages Margarita Putniņa and Oksana Mališeva.

Professional foreign language teaching

Associate professors of the Department of Languages Sarmīte Bremze and Daina Grasmane have investigated the problems of the study process and adult education, students' and labour market needs regarding foreign language skills, students' competences, cross-cultural communication and others. S. Bremze and D. Grasmane have had joint publications with John Hobrough, the visiting professor of Surrey University (UK), on the recognition of cultural diversity and the impact of the Bologna process on the development of higher education system and its reforms in the Eastern Europe at the end of the 20th and the beginning of the 21st centuries.

The academic staff of the Department carried out the needs analysis research for improving professional foreign language teaching/learning. Alongside with the identification of the requirements of the working environment, it is also very important to identify students' individual needs and their attitudes towards foreign languages as means for development of their professional, intellectual, cultural and social competencies. Therefore, since 2003, on a regular basis, research studies have been conducted by researchers at the Department of Languages of the Latvia University of Agriculture (LUA) to identify the above needs: Ozola (2003, 2012), Parcinska (2006), Knope (2011), Malinovska (2011), Grasmane D. and Grasmane S. (2011, 2013), and others. Their findings revealed that the learners' needs were impacted, firstly, by the national and international labour market current and prospective needs and, secondly, by the intercultural communication needs of a multicultural society and individual needs.

Selections of contemporary terminology developments in publications in German on water and air pollution, protection of the environment including publications on chemistry, biology, geology, medicine were reflected in several Latvian–German–Latvian dictionaries by lecturer Raisa Sipoviča in cooperation with Lilita Ozola (Sipoviča, Ozola, 2005; Sipoviča, 2009). Lecturer Dace Skrupska

took part in the elaboration of "English – Latvian – English Forest Sector Glossary" (2007). Larissa Turuseva published the text book for learning political terminology "Political Readings: An Entertaining Journey from Academic Indifference to the Joy of Intellectual, Societal and Personal Discovery" in 2012. Assistant professor Inese Ozola defended her Doctoral thesis analyzing the speech processing in foreign language "Linguistic and Pragmatic Preconditions to Processing Transactional Spoken Discourse in a Foreign Language" (2007).

In 2003–2006, Larisa Maļinovska was the project coordinator in the Leonardo da Vinci project "Team Teaching – Transfer and Boundary Zones in Content and Language Integrated Learning" (Latvia, Finland, England, Poland, Spain). Daina Grasmane *et al*. concentrated on innovative means for fostering foreign language acquisition analyzing the advantages of online learning as compared to blended learning and the conventional group work.

Internationalization of the study process

The research of the Department addresses the issue of the necessity to enhance the development of multilingualism in Latvia, as, in accordance with the EU language policy, each EU citizen should be able to communicate not only in his/her mother tongue, but also in, at least, two other languages. Developed language skills ensure greater employability in the long run and can lead to better job opportunities. In addition, Erasmus mobility programme requires good foreign language proficiency and relevant academic skills.

Since 2005, international scientific conferences "Students on their Way to Science" have been organized by the members of the academic staff Larisa Maļinovska and Anete Mežote for undergraduate, graduate and post-graduate students of the university with representatives from about 17 countries participating every year. These conferences are aimed at dissemination of scientific research results, sharing of experience, improvement of foreign language and cross-cultural communication skills, and establishing of international contacts for further co-operation. Also the collection of abstracts is published and indexed in CAB Abstracts. Besides, the workshop of the reports in the English language is held at the Faculty's annual students' scientific conference "Youth in Science and Professional Practice".

To draw attention to necessity of intercultural approach in social life, which also meant learning and recognition of differences of cultures, traditions and values, the conference "Multicultural Communication and the Process of Globalization" was organized in 2003. The attention was paid to advantages and disadvantages of the processes of globalization. The conference was organised by the Department of Languages together with the Sonnenberg Organisation, Germany. The main topics for the discussions were multicultural environment, assessment of values and teaching/learning of professional language, and the role of communication. In April 1–12, 2006, Larisa Maļinovska and the Dean of the Faculty of Social Sciences Jānis Ābele, being members of the Baltic Sea Network, organized the pilot project "Promoting Intercultural Management Competences in the Baltic Sea Region PIM 2006" at the Latvia University of Agriculture with students and teachers from Latvia, Lithuania, Estonia, Russia, Denmark and Finland participating. Lecturer Anete Mežote is working at her Doctoral thesis on the topic of the development of international cooperation competences of external relations specialists.

Teachers of the Department of Languages are not only organizing scientific conferences at the Latvia University of Agriculture, but are also attending international conferences abroad in the countries all over the world, presenting and publishing their scientific research results.

Thanks to the support of the European Union funds, the teachers Inese Ozola, Olga Čivžele, Larisa Maļinovska, Anete Mežote, Daina Grasmane, Larisa Turuševa, etc., have attended conferences and published articles in such faraway countries like Hong Kong, Singapore, Colombia, United Arab Emirates, Canada, etc.

In 2011–2013, the members of academic staff Inese Ozola, Anete Mežote, Ieva Knope, Larisa Maļinovska and Diana Svika participated in the two-year (2011–2013) Grundtvig Learning Partnership Project of seven countries "Visualisation – Highlights in Language Teaching".

Development of professional competence

Higher education institutions carry out the function of professionalization of the young specialists, therefore the lecturers of the Department of Languages in their research pay great attention to mastering of methods of teaching, which allows to assist the students of the study programme "External Relations" acquire professional and scientifically methodological competences in the university study process. Development of professional competences of students of "External Relations" was the theme of assistant professor Larissa Turusheva's PhD thesis. Olga Čivžele is carrying out her doctoral research on the development of study competence for the first year students of the Latvia University of Agriculture.

In order to raise the quality of teaching/learning process and to develop students' learning competence, I. Gode studied hypertexts as a means for the development of students' ability for independent studies and O. Mališeva – the history of the development of professional foreign language competences in their doctoral theses. Research topics of associated professor Larisa Maļinovska are related to the development of engineering student skills and competences, independent work and student autonomy in learning, CLIL (Content and language integrated learning), motivation issues and other relevant fields.

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Pedagogy Science at the Faculty of Engineering

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Abstract. Pedagogy is one of the scientific fields carried out at the Faculty of Engineering. Pedagogy is developed at the Institute of Education and Home Economics (IEHE) and comprises four subfields: school, adult, university, and fields pedagogy. The main research directions are: ecology of education, competence in rural environment, professional and career education, life quality in the context of home environment, science and engineering sciences didactics. Studies reflect mutual interconnection among the directions and interdisciplinary link between pedagogy and other sciences. The aim of the article is to reflect the development of the main research directions of pedagogy and IEHE staff and doctoral students' investigation results till 2013.
Key words: Pedagogy science, education, rural development.

Introduction

Pedagogical research intentions started with the foundation of the Department of Languages-Pedagogy at the Latvian Agricultural Academy in 1940. A famous Latvian pedagogue and scientist Jūlijs Aleksandrs Students was one of its heads from 1944 to 1945.

Active scientific research in pedagogy started in the 1960s at the Faculty of Agricultural Mechanisation. Investigations were in the field of professional education and subject didactics. The investigation results were implemented in practice on the level of running of higher education subjects and continuing education courses for vocational agricultural/technical schools teachers and lecturers of the former Soviet Union's higher education establishments, as well as in regular courses for lecturers of the former Latvian Agricultural Academy. The first dissertations in pedagogy were defended by a lecturer of the Department of Tractors and Automobiles Jānis Blīvis (Бливис, 1967) and by Ilmārs-Žanis Klegeris (1972).

Research and academic work were the basis for renewal of the Department of Pedagogy in 1989 and for the foundation of the doctoral programme of pedagogy under the guidance of prof. Ludis Pēks. In 2000, the Institute of Education and Home Economics (IEHE) was founded on the basis of two departments: the Department of Pedagogy, and the Department of Nutrition (home economics part).

Five dissertations in pedagogy (Pēks, 1992; Briede, 1996; Zeidmane, 1996; Dišlere, 1997; Aizsila, 1998) were defended in the period from 1992 to 2000.

Scientific research of IEHE is in line with the LLU and Zemgale Planning Region development programmes, which in the field of education focus on the following key words: intellectual potential and culture, cooperation of institutions, all levels education, and rural areas. Therefore five research directions of IEHE are closely related to rural development problems.

Ecology of education

The direction is carried out by prof. Ludis Pēks, assoc. prof. Irēna Katane, doctors of pedagogy Ilze Kalniņa, Anna Laizāne and Regīna Baltušīte, doctor's degree applicants Dace Peņķe and Ruta Renigere, and doctoral student Sandra Īriste.

It is an interdisciplinary direction based on the ecological paradigm which is also an interdisciplinary phenomenon nowadays.

The studies of the direction to a large extent serve as a theoretical basis for researches of professional and career education, pedagogical aspects of competence, and home environment problems.

Systemic investigations on the topicality and problems of the direction have started since 1996. Prof. L. Pēks and assoc. prof. I. Katane worked out the definition of ecology of education as *'.. one of the trends of Human Ecology that is the interdisciplinary integrating natural, social and humanitarian sciences, which studies a human as an individuality and/or social systems, including their development and fluctuation, within interaction with changeable multi-dimensional and multilevel surrounding environment in a holistic perspective in the aspect of education, where education is: a sphere of human/social system's activities; promotion means for sustainable development; process and result; interaction system, content of interaction; environment; human and environmental quality/characteristics'* (Katane, 2005; Katane, Pēks, 2006, p. 34).

Assoc. prof. I. Katane (2005) has worked out the research methodology of rural schools and the evaluation model of educational environment of rural schools.

Ecological paradigm of education has been analysed and its principles have been substantiated focusing on the concept of environment as a central category; conceptions of sustainable development in interdisciplinary researches and complementarity of conceptual approaches in nowadays education have been studied as well. Systemic approach of working out structural models of educational environment has been developed: a multidimensional and multifunctional model of school environment, three aspects of humanistically targeted school educational environment interaction and ecosystem model of human education have been worked out. A multidimensional approach of research, analysis and evaluation of educational environment has been carried out (Katane, 2007).

A continuation of studies on the diversity and changeability of the rural schools' educational environment (2008–2012) includes the following results. The research paradigm for a rural school as an educational environment has been developed comprising: the substantiation of the concept *a rural school*; the substantiation of the fluctuation of a rural school as a viable, self-developing, self-organizing system of educational environment; the substantiation of a rural school as an open humanistic target-oriented lifelong education environment for the sustainable development of a community; the substantiation of a rural school as a knowledge organization (a learning organization), including the scientifically substantiated concept *cross-school mentoring* and its methodology. There has been developed the methodology for the evaluation of the educational environment of rural schools and substantiated the diversity of the models of the educational environment of rural schools and, by means of the method used for the modelling of educational environment, there has been developed the classification for four basic groups of these environmental models. There has been experimentally approbated the methodology for the evaluation of the educational environment of rural schools (including the development of worksheet for the experts). There has been experimentally approbated the methodology of cross-school mentoring (Laizāne, 2012; Katane, Laizāne, 2012; Katane, Laizane, 2012).

In the field of secondary school pupils' competitiveness within the non-formal commercial education, the scientific substantiation of the notions of personal competitiveness and competitive

specialist, the structural model of competitiveness and diagnostics and indicator systems of evaluation of competitiveness have been worked out, as well as the environment non-formal commercial education as a system of multi-level environment has been substantiated (Kalniņa, 2010; Katane, Kalniņa, 2010).

The readiness of pedagogy students as prospective teachers for their professional activities in the school environment has been substantiated, as well as the structural model of the readiness of pedagogy students as prospective teachers for their professional activities in the context of educational environment, and the methodology for the self-evaluation of pedagogy students' readiness for professional activities based on the above mentioned model have been developed; on the basis of ecological approach in the educational research, the conception of the pedagogy students' practical training in the school environment has been developed (Baltušīte, 2013; Katane, Baltušīte, 2007).

Since 2011, the studies of the environment of distance education are being carried out with the emphasis on the educational institution as the distance education environment in a multicomponent/ multicontextual system. Informative environment, technological environment, and e-environment have been analysed as complementary contexts of distance education, as well as the development of the history of distance education has been studied.

Competence in rural environment

The direction is carried out by prof. Baiba Briede, doctor of pedagogy Inese Bīmane, doctor's degree applicants Vilnis Tomsons and Tatjana Šinkus, and doctoral students Imants Bērtaitis and Iveta Kokle-Narbuta.

At the end of the 1990s, theoretical and practical research of competence as a topical pedagogical category was started. The aspects, kinds and components of competence in relation to micro-, meso-, exo- and macrosystems, five pillars of education, knowledge society tendencies and features, and constructivism approach in education have been evaluated as a necessary precondition for the development of today's specialists (Briede, 2009; Briede, Pēks, 2011a, 2011b).

Professional competence features and reaching of them during the study process of geodesy have been studied (Bīmane, 2012; Bīmane, Briede, Pēks, 2012).

The model of further education for the development of agricultural adviser's competence has been worked out (Laitāne, 2003).

Studies on adequacy of professional, higher and adult education implementation to the UNESCO *Education for Sustainable Development* (ESD) principles and *European Qualifications Framework have been carried out*. Eligible expert evaluation, the model of competences of labour protection specialists, the model of pedagogical competence of labour protection specialists, and the model of ecological competence of nurses, based on ecological approach in education, are worked out. Study programmes, based on the models, are implemented in several colleges and higher schools in Latvia (Bērtaitis, Briede, Pēks, 2012; Bērtaitis, Pēks, Renigere, 2012).

Professional and career education

The direction is carried out by prof. Ludis Pēks, assoc. prof. Anita Aizsila, doctor of pedagogy Irēna Kuliša, doctoral degree applicant Inita Soika, doctoral students Imants Bērtaitis, Dace Brizga, Jānis Pāvulēns, Ruta Renigere, and Gita Stalidzāne.

Research in the sphere of formal as well as of non- and informal education is carried out in co-operation with other structural units of the LLU, Latvian higher schools, Latvian professional secondary education schools and colleges, as well as with foreign educational institutions.

The changes in the Latvian vocational education system are analysed from the approach of regional development and methodical proposals are developed for preparation and assessment of four scenarios for the development of the vocational system of education, as well as their assessment criteria are defined (Sēja, 2008).

Possible formation of world view (*Weltanshauung*) in vocational school students has been substantiated, identified and corroborated. A structural model of world view is created, and the opportunities of formation of the world view in vocational education are described and analysed (Augškalne, 2012).

In the Network for Innovation in Career Guidance and Counselling in Europe (NICE), project counselling and methodology for university students' career development has been substantiated and assessed.

In the field of further education of pedagogues, the strategy of further education of pedagogues and the quality of education and improvement of professional competence of pedagogues are studied (Aizsila, 2012a, 2012b).

Life quality in the context of home environment

The direction is carried out by assoc. prof. Vija Dislere, assist. professors Iveta Līce, Aija Pridāne, and Nataļja Vronska, doctor's degree applicant Silvija Reihmane, and doctoral student Elīna Kūla-Braže.

Life quality conceptions, theories and their development trends, as well as life quality multi-dimensional aspects as social, economic, political, welfare, safety, sustainability and life quality indices, its objective and subjective criteria; human potential development index and its components: life time, health condition, welfare level, etc.; quality of life in the context of ecosophy and ecology; correlations of primary (raw materials, natural environment) and secondary (things created by people) environment and its influence on personal development are assessed from the aspect of home economics.

Several studies have been devoted to evaluation of consumption, its alternatives and influence from the point of view of philosophy, ecosophy, psychology and economics, as well as to the positive and negative aspects of consumer education, the didactic process of creative approaches to the consumer citizenship education (Lice, Dislere, 2009; Dislere, Lice, 2008). The investigations of responsible living in home economics education, and social innovation for stimulating sustainability have been carried out (Līce, 2011; Dislere, Lice, 2009). In this respect, there are many investigations in home economics education development problems: content to be acquired, aim, co-ordination of tasks and results, formation of creativeness and self-realisation need, socialization and culturalisation processes in the context of life quality considering economic, spiritual and cultural criteria. The principle of life quality in home economics education has been substantiated, and innovative content in the school subject "Home economics" has been developed in the context of life quality (Pridāne, 2009, 2012).

In the field of home economics and ICT integration, teachers' ICT integration skills have been defined; levels, criterions and indicators characterizing development of ICT

integration skills in Household and Home economics and scientifically grounded model of ICT integration skills development for prospective teachers of Household and Home economics have been worked out; and the methodology of ICT integration to improve the content of study courses with pedagogical recommendations, newest ICT and usage of different specialized computer programs for Household and Home Economics in the study sub-programme "Home environment and informatics in education" have been worked out (Vronska, 2012a, 2012b).

By the study in Jelgava region 13 municipalities, a resume of non-formal education activities offered there have been worked out, and the demands and potentialities of rural women have been studied. The study evaluates the life quality in Latvian rural areas in the last seven years. The study is based on results gained in Latvia–Lithuania cross-border cooperation programme project ECOART guided by lecturers Zane Beitere-Šeļegovska and Ligita Ozolniece.

Science and engineering sciences didactics

One of the aims of the research of the Department of Mathematics is to study general competences of becoming engineering specialists necessary for their carrier, as well as to study importance of ICT technologies and mathematics in engineering education and to investigate disciplines which could be integrated in the engineering education to develop the competences. That way interdisciplinary approach is implemented. Mathematics studies have an impact on the development of the necessary outcomes for engineers both directly (mathematics serves as a tool for solving and calculating various problems) and indirectly (mathematics develops skills to formulate and solve engineering problems) (Zeidmane, 2011, 2012; Zeidmane, Čerņajeva, 2011). Methods of modules in physics for engineering students are developed (Zeidmane, 1996).

The principles of exemplary studies of geodesy studies are assessed and adapted, and the appropriate didactical model of geodesy studies is worked out (Bīmane, 2011, 2012).

Conclusions

Researches in each particular IEHE scientific direction will develop considering humanistic paradigm and the knowledge society developmental aspects in line with the vision, aims and strategic plans of LLU and Zemgale Planning Region.

Research should be carried out in co-operation with Latvian and foreign partner universities and with local and national authorities involved in research projects and other types of agreements, and results should be published in monographs and issues indexed in international scientific data bases.

Involvement of young scientists should be promoted in order to keep the research and academic work continuity at IEHE.

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Rural Space as a Subject of Sociology Research in Latvia

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Abstract. Rural sociology is one of those fields of sociology which has rather long history when compared with other fields or research. From today's viewpoint it is possible to identify several periods in the development of rural sociology in Latvia: 1) up to 1940; 2) 70s–80s of the 20th century; 3) beginning of the 1990s up to the first decade of 21st century; and 4) recent years outline a new period. Each of these periods has its specific character as regards the organization and the problems because of the change of the political, economic and social conditions. The first stage focused on the peasantry as a class analysis, the second stage analyzed the problems of structure and functioning of rural society developed in the condition of socialism, the third dealt with the peasantry as a group revived as the basis of rural population moving to the individual farming, identifying favourable factors and obstacles of this movement. The research of the fourth period centres on the rural areas as a system and mosaic type formation. At the initial stage, research was carried out by agricultural specialists, at the second and third stage – by economists, historians, and philosophers, and now – by academically educated specialists in sociology, regional development, human geography. In the course of time, the Latvia University of Agriculture has developed a group of researchers with a focus on social problems of rural development considering that rural development is determined not only by the physical and financial, but also by human resources. The authors' research overview is based on the perception of rural areas as space.
Key words: Rural space, rural sociology, research stages, research issues, research centres.

Introduction

Rural sociology is one of the fields of sociology science in Latvia which in comparison with other fields has relatively recent history. The first publications appeared in the 20s of the 20th century.

The emergence of rural sociology in the pre-war Latvia (before WWII) has been determined by several factors. First, as Latvians have been a people of peasants for centuries, they have always had a desire to possess the land. When Latvia obtained political independence in 1918, the pre-conditions for a radical agrarian reform and strengthening of peasantry as social entity were created. Thus, peasants and their environment, the countryside, were considered to impersonate the values of Latvian traditional way of life in the Latvian people's perception.

Second, the majority of the Latvian population at that time lived in the rural areas of Latvia and agriculture production was the main industry of Latvian economy, therefore largest producers exported their produce to other countries. Thus, rural people and the countryside became a source of wealth of the country.

Third, sociology as the method of society analysis developed worldwide and, as Latvia was not an isolated territory, the information about the research developments in other countries reached Latvia. The focus of research in Latvia was on rural areas and rural inhabitants, which at that time were mostly peasants. The link between the international and Latvian academic community was

reflected in scientific publications of the 1920s and 1930s, where the authors in their theoretical analysis included references to such authors of the Western world as Piterim Sorokin, Ferdinand Teniss, and Charles Gelpin.

From today's point of view, the development of rural sociology can be divided into several stages:

1) the first stage refers to the time period before 1940, which could be called pre-history;
2) the second stage might be referred to the 70s–80s of the 20th century;
3) the third stage started in the 90s of the 20th century and lasted till the second half of the first decade of the 21st century;
4) the fourth stage started approximately with 2008/2009.

Each of the stages has its specific features concerning organizational and thematic issues, since political, economic and social conditions have been changing. The background and skills for carrying out research in sociology of the researchers involved in sociology have transformed. The present paper is an attempt to analyze the development of the research in sociology focusing on the thematic aspect of the research topics rather than on the contribution of each individual scientist. The issue of authors could become an objective of another paper elaborating on the history of rural sociology in Latvia.

First stage of rural sociology

The research performed in the 20s–30s of the 20th century has not been deeply studied. However, it is possible to claim that the origins of rural sociology date back to the period of the independent state in the first part of the 1920s. The scientists focused their attention on the defining peculiarities of rural life in comparison with urban life and linked it with birth rate, life expectancy, the structure of age and gender, marital status, occupation, as well as crime rate of the population. The above-mentioned issues were analyzed in terms of the historic regions of Latvia (Ceihners, 1937).

The second and the most important issue of the research at that time period was the groups of land owners before and after the Land Reform of 1922, which brought significant changes to the rural areas of Latvia. The reform disabled landlords from their huge properties of land and created a large layer of smallholders and small farmers in rural areas. The basic criterion of the division of peasants into groups was the size of land they had obtained; thus, according to the authors' opinion, the peasantry was divided into large farmers, middle-sized farmers, smallholders, and small farmers. The publications of those years defined the differences in inner groups and characterized the condition of peasantry in comparison with other classes of society. The availability of statistic data gave information about additional occupations of farmers (smiths, millers, craftsmen, etc.); on the other hand, agriculture became an additional source of income (an owner of a farm could be employed either in various state and self-government institutions, or become the so-called representative of free professions, or could be engaged in trading activities, etc.) (Birkerts, 1921; Skujenieks, 1927; Ceihners, 1937). The groups of peasants in several publications were analyzed in regional terms (Līkais, 1939, 1940).

Wage labourers, involved in agriculture, were analyzed as a specific social group of rural areas of Latvia. The composition of farmhands, their regional peculiarities, and sources of hired labour force were analyzed; the data of Latvia and other countries (Estonia, Lithuania, Eastern Prussia, Denmark) were compared. The reasons of the trend were analyzed when surplus labour force

from smallholds and small farms (1–5 ha) was not willing to work in large farms, even though there was a lack of labour force, causing import of the labour force from other countries, especially from Lithuania and Poland (Ceihners, Starcs, 1929).

Since the above-mentioned authors were economists and an agronomist, the stratification of society and social mobility problems were described in economic categories applying mostly objective criteria. However, in several cases, sociological research methods were used carrying out farmers' surveys regarding periodicals' subscription, participating in social organizations, children's opportunities to obtain education, etc., or interviewing rural people about their reasons to moving to the capital city, in a nutshell, asking the information which was not possible to obtain by means of statistics (Starcs, Līkais, 1940).

The further analysis of the heritage of the 1920s–1930s could reveal some undiscovered publications on rural social life and will enrich our understanding of the research of those years. In conclusion, the pre-history of sociology is the result of individual scientists.

Main research directions in the 70s–80s of the 20th century

The second stage of the rural sociology started only after 25–30 years. Three occupations, the deportations (1941, 1945, 1949), and the forced collectivization did not form relevant political, economic and social environment, when authorities could receive a "positive" feedback about the social processes. As regards negative opinions, they were feared of. Therefore sociology research came to a halt. The revival of sociology as science, including rural sociology, started only with the second half of the 1960s. Moreover, rural sociology occupied a stable and significant place in the research in the 1970–1980s.

First, it is a structure of social classes and a professional structure of rural society, particularly the groups involved in agriculture production. Primarily the focus was on the analysis of employees of state farms and collective farms, namely, agriculture specialists (Rivža, Krūzmētra, 1985) and main groups of manual workers – machine operators and cattle-farm workers (Vedļa, 1984).

Second, it was agriculture work. The increasing youth migration to towns, the problem of staff changeability in farming enterprises and unsatisfactory production outputs resulted in the analysis of agriculture work: the content of work and work conditions, organization of work, professional orientation towards agriculture work, professional training, and other issues related to work (Porietis, 1956).

Third, some publications concerned the analysis of ways of life. The articles analyzed living conditions and culture environment in the countryside, as well as conditions of social infrastructure and formation of villages from the point of view of urban–rural linkage (Porietis, 1973; Timofejevs, 1980, 1982, 1987; Pavlovs, 1979; Kozlinskis, 1984; Krūzmētra, 1976).

In those years, the research dealt with the analysis of the needs and meeting the needs of agriculture employees. The analysis was carried out twice – in 1975, and in 1990. The research identified 24 needs, which were divided into six groups – the needs related to job, psychological comfort, welfare, valuable pastime activities, appropriate living conditions, and intellectual culture. Thus, the comparative research was carried out for the first time to analyze a phenomenon's dynamics: both on the whole and in separate groups (Krūzmētra, Rivža, 1992; Mūrnieks, 1979; Pavlovs, 1979).

At the beginning of the 1970s, the social development projects for the staff were launched. These activities reached the countryside as well. However, in rural areas, the projects or plans

should have become not only the development documents of staff, but also of the territory, since it was not possible to separate the life outside work of agriculture and other employees from work. However, the idea was quickly turned into a formal "administrative initiative", therefore staff members of the farms and the society on the whole soon lost interest in it (Krūzmētra, 1974).

Concerning the organizational aspect of the research activities in the time period of the 1970s–1980s, small groups of researchers worked at the Riga Polytechnical Institute, the Latvia State University, and the Latvia Agriculture Academy. However, in the course of time, the Latvia Agriculture Academy (LAA) became a centre of research, which was determined by several conditions. First, the profile of the institution envisaged education of highly qualified agriculture specialists. Second, biennial scientific practical conferences on the issues of rural social development were held at the LAA with the subsequent publication of conference proceedings. Third, at that time the researchers' group of the LAA expanded cooperation activities with research centres in Estonia, Lithuania, Belorussia, Ukraine, and Russia (Moscow, Leningrad, Novosibirsk, Vologda). Since 1975, Rural Research Group in the Baltic Department of the Association of Soviet Sociologists was set up to organize sections for rural problems in scientific conferences.

However, today's perception makes us look at the research conclusions not only from the positive side. The publications of that time were ideologically biased. For example, the articles on the trends of social class structure development mostly singled out the common features of the groups and tendencies of "merging" (disappearance of differences is the result of administrative measures, for example, between employees of collective farms and state farms). Meanwhile, the silence was kept (it was forbidden to research) on the formation of new groups and differentiation of society in relation to the levels of power. On the other hand, the description of the formation of villages was mostly based on the representatives of population interested to move to villages rather than those not willing to do so.

The research lacked a complex approach. The countryside was not analyzed as a social and territorial unity integrating the whole range of problems. The analysis did not include such groups of population as employees involved in medicine, education, communications, trade, building, land reclamation, consumer service, public administration and others all together constituting rural society. The Census of 1970 showed that only 55.3% of all rural inhabitants were employed in agriculture and forestry, but 44.7% were employed in other areas of economy. If the data of the group involved in other spheres were not available, the correlation analysis of social environment was impossible.

An edition of most significant sociological research in Latvia has not been published yet due to little demand for sociological information. The executives of authorities lacked sociological competence to deal with the research findings. The information providing instant economic or political effect was mostly demanded.

Finally, it is necessary to mention that there was insufficient funding, equipment and information processing software to perform the research. In addition, the research was performed by people without professional sociological education. Concerning background education of the researchers, they were agriculture professionals, historians, economists, philosophers, lawyers, and representatives of other specialities who acquired knowledge and skills in sociology independently being enthusiasts of this field of research.

Most typical directions of research starting from the 1990s

The transformation of Latvia to new economic and political principles, restoration of the private property, the implementation of the agrarian reform in the countryside caused new development in rural sociology, and the 1990s marked the beginning of a new stage.

First, new themes emerged in the research. Comparing with the previous development stage, such new social notions as farmers, craftsmen, entrepreneurs, and hired labour force appeared, and researchers paid their attention to these new groups. The focus was on the rebirth of peasantry as the basic group of rural population in time and space. The analysis addressed the following issues: how large part of the population was willing to start up individual business, what kind of population groups became farmers, what was the pace of formation of peasantry, what factors influenced and what factors hampered this process. The advantages of specialists of former collective farms in conditions of individual farming were analyzed, and future opportunities of "farmers living in the towns" were described (Krūzmētra, Rivža, 1993; Tīsenkopfs, 1996). Since peasantry was composed of the people with various educational and professional backgrounds, training issues became very important, therefore activities of the Latvia Advisory Service and farmers' attitude towards it were studied (Tīsenkopfs, Zobena, 1995; Tīsenkopfs, 1999).

Instead of finding proof for merging tendencies in the social structure as it was required by the previous ideology, the differentiation process, horizontal and vertical mobility, stratification of rural society on the whole and among farmers were researched (M. Krūzmētra, B. Rivža).

Since the changes in society had an impact on all its elements and had qualitative features, an integrated view and territorial approach became a dominating method, i.e., rural area became the subject matter of the research instead of agriculture. The transition from production analysis to territorial analysis took place. This is why self-government of parishes and districts and their role in the social development of their administrative territories, activities of non-governmental sector and its influence were studied (Krūzmētra, 1999).

The issue of rural women had become the subject matter of more frequent attention – their place and status in society and family were studied. The research on women, including rural women, had expanded all over the world, and this tendency was characteristic in Latvia as well (Krūzmētra, 1992, 1994, 2000, 2003).

On the whole, as regards the content of research, two directions of rural sociology became apparent. One of them focused on the issue of space – the analysis of rural area as social territorial unity was performed (Krūzmētra, 1998, 2000, 2003), the second direction focused on the study of agriculture as a feature characterizing the countryside, sustainable agriculture policy, and conditions of biodynamic agriculture development (Zobena, 1999, 2005).

Second, administrative institutions, the Ministry of Agriculture and the Ministry of Environment and Regional Development, self-governments of several districts and parishes became interested in sociology, particularly in relation to elaboration of administrative territorial structures. Even though the circle of people involved in rural sociology was narrow, new trends were apparent. Professional people with sociology education and a scientific degree turned to the investigation of rural problems. The scientific conferences dedicated to rural problems were arranged at the Latvia University of Agriculture after a short break.

The previous period was characterized by the establishment of contacts with eastern neighbours of Latvia, but during this period cooperation was established with researchers in

the western direction – Denmark, Sweden, Finland, Norway, Germany, and Ireland. As a result, Latvian rural sociologists became participants of several international research programmes.

The rural research had moved forward; however, several problems had not been solved yet. There were several methodological questions. The concept of "rural area" used in Latvia is too narrow for the existing situation. Urban issues were still the priority, even though the process of re-urbanization or counter-urbanization was an issue of studies in many European Union countries; the same could be said about Latvia. The issues of rural areas began to disappear as a self-dependent research entity, as an integrated system; it was often substituted with regional analysis concentrating on average indices (including cities, towns, and rural areas) thus achieving rather balanced regional indices.

The number of researchers engaged in rural sociology was still quite small. In addition, funding and equipment for performing research, participating in conferences, and the publications of the results of research were not sufficient. The research activities should be elaborated on.

Fourth stage in the development of research on rural issues in sociology of Latvia

The second decade of the 21st century can be considered as the 4th stage in the rural research in relation to political, economic and sociological issues. The combination of three events influence it: the accession of Latvia to the European Union, the establishment of contacts with the researchers worldwide, creating new approaches in rural research, and the world economic crisis. The focus of research has changed. The situation now shows that research issues seem to have changed the priorities comparing to the end of the previous stage. Such notions as rural development diversification, caused by rural economics diversification, and farming diversification are analyzed (Šūmane, 2010; Krūzmētra, Rivža, Rivža, 2011). Other branches of economics such as processing of agriculture products and various services have become increasingly popular along with agriculture production in rural areas, due to which labour market has been studied (Rasnača, 2011, 2012). Innovative applications are evaluated: ecological farming, food chain shortening, inclusion of culture heritage in rural and agrotourism product (T. Tīsenkopfs, S. Šūmane, M. Krūzmētra). However, the issue of rural space as an entity, as a system, as space capital or holistic integral research has become the most important tendency in the rural research, first, from the socio-economic aspect (Krūzmētra, 2010, 2011; Rasnača, Paula, 2007), and, second, from socio-psychological, socio-political and culture aspect (Proceedings "Dzīve – attīstība ...", 2012). The choice of research themes reflects the common trends in rural research issues in Latvia and in Europe (Ploeg *et al*., 2000, 2008; Woods, 2012).

The previous research is continued. The research problems are the following: regional development (Tīsenkopfs, 2008, 2010; Zobena, 1999), specific social groups, the retired people (Grīnfelde, 2010), small towns (Bite, 2010), significance of social capital (Igaune, 2012).

The research has raised awareness of rural area as a mosaic (peri-urban), influencing the research directions and involving new researchers with academic degree in the rural research.

The main problems for further research to be continued could be the following:

1) activate cooperation of researchers involved in rural research, creating preconditions for more extended research projects, expanding the scope of the research topics;
2) expand rural research on the basis of space capital, applying an integrated approach in the analysis of the processes and their interaction in the researched territory;

3) activate the presence in cross-border research thus providing an opportunity for comparative analysis in the rural regions of Latvia and of neighbouring and distant European countries to look for similar features, in order to see positive tendencies and find problems where Latvia is lagging behind.

The research activities on rural issues will contribute in the sustainable development of rural space.

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The Latvian Academy of Agricultural and Forestry Sciences Consolidates Stakeholders in the Sector

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The Latvian Academy of Agricultural and Forestry Sciences (LAAFS) was established in 1992 to promote the integration of agricultural and forestry sciences and higher education and their joint contribution to practice and production. The LAAFS represents the fields being very important to Latvia, as forests and agricultural land are the most abundant resources of its national economy and natural endowments. Besides, the agricultural area per capita is considerably greater than on average in the world and on average in Europe, and, according to Eurostat, Latvia with 56% forest area is the fourth most forested European Union Member State and the most forested country among the Baltic states. Therefore, given the increasing demand for food and ecological balance in the world, Latvia has a potential, the value of which rises from year to year. At the same time, the role of science and scientific structures increases, especially in relation to interdisciplinary research, innovation, public education, and the resource-saving way of thinking and such actions.

The establishment of the LAAFS was associated with the special post-Soviet period when the transformation of economic life began along with political changes during the first years of the independent Latvia. While making the new agricultural policy – land privatisation and restitution to the former owners, farming under a free market, etc. – as well as transforming higher education and science in this sector, closer cooperation was simultaneously established among all the stakeholders influencing the sector [1].

Particularly scientists themselves, especially those from large agricultural institutions, wished to be consolidated in a single organisation uniting agricultural sciences – the Latvian Academy of Agricultural and Forestry Sciences. Yet, it has to be mentioned that the establishment of the new scientific structure did not take place fast and easily – discussions about it lasted for two and half years. A strong motivation in uniting the stakeholders was the wishes to get scientists to be listened to and involve them as consultants in designing and making the new agricultural policy. However, for this reason, first, the scientists themselves had to become more united by not strictly disassociating their scientific structures from the leading university – Latvia University of Agriculture (LLU) – and the scientific structures of this university. Quite soon, several agricultural scientific institutes of Latvia were integrated into LLU. Convergence with international practices took place, and researches of national significance were carried out based particularly on the academic environment.

After the issue of establishment of the LAAFS had been coordinated with the government and a positive response had been received from the then prime minister and the present European Parliament member Ivars Godmanis, the initiative of establishing the academy was taken over by LLU in which the majority of former scientists worked. On the day of establishment of the LAAFS, 4 June 1992, the then LLU rector Dr.oec. Voldemārs Strīķis was elected the first president of the

Table 1

The number of LAAFS full members by year of election in 1992–2013

Year of election	1992	1994	1995	1997	2000	2002	2004	2006	2008	2010	2013
LAAFS members by year of election	29	4	6	3	12	16	11	16	6	5	7
Total number	**115**										

academy, and Dr. habil. agr., Dr. med. vet. Aleksandrs Jemeļjanovs, who performs these duties until present, was elected the vice-president. As regards the leading role of LLU in forming the new scientific structure – the LAAFS –, one has to note that it is just logical, as the predecessor of LLU – Peter's Academy in Jelgava or *Academia Petrina* founded in the 18th century – was the first scientific institution in Latvia.

We have also international members [3].

The initial most significant achievements of the LAAFS are related, first of all, to establishing a wide range of contacts, thus gaining a good reputation among scientists. The LAAFS integrated into the organisational system of scientific activity, and fruitful cooperation emerged with the Latvian Academy of Sciences, the Latvian Council of Science, ministries, and many other institutions in Latvia as well as in Sweden (the Royal Swedish Academy of Agriculture and Forestry) and in Russia (the Russian Academy of Agricultural Sciences), and with agricultural scientific structures and scientists and international organisations of Finland, Romania, Estonia, Lithuania, and other countries. Regular meetings of the heads of agricultural universities of the Nordic and Baltic countries were and are still held. Presently, the LAAFS has signed more than 10 international agreements with academies of agricultural and forestry sciences or similar institutions of other countries (www.euracadagri.com).

Second, under these new political and economic conditions after independence was regained – when agricultural output sharply decreased, whereas forestry, in contrast, productively developed, and when times were problematic for science and the number of scientists declined – the LAAFS maintained the professional, intellectual, and scientific potentials of these fields by consolidating agricultural and forest scientists. Since the first days after its establishment, the academy has elaborated various conceptions and programmes for restructuring scientific institutions and ensuring their effective operation, as well as has developed scientific recommendations in the issues of agricultural production and the new economic system, thus mitigating the crisis situation and avoiding even a greater decrease in agricultural production.

Third, the LAAFS contributed to the development of academic studies and research by coordinating scientific activities in the sector, integrating the activities of LLU and other scientific and research institutions and their scientists, and developing interdisciplinary and inter-institutional cooperation. For instance, it resulted in the establishment of an institution of national significance – the Food Science Centre, and scientific contributions were dedicated to these themes. One of the three research programmes targeting interdisciplinary problems was entitled "Unpolluted

and High-value Food: Quality Criteria and Competitiveness"; the other two programmes were as follows: "Raw Materials from Wood and Plants" and "Quality Assessment of Forest Resources in Latvia and the Development of Theoretical Fundamentals for Increasing the Quality of Forest Products and Technologies for their Rational Use". To implement these programmes, agricultural and forestry scientists from also other universities – Riga Technical University (RTU) and the University of Latvia (LU) –, as well as other prominent scientists were engaged.

Later a programme of national significance "Scientific Fundamentals for Agricultural Development in Latvia" was elaborated, which integrated six important research programmes. The research results were published in a scientific monograph, the size of which was almost 1000 pages [2]. All the departments of the LAAFS significantly contributed to the coordination of scientific research, held many seminars, conferences, published research papers and conference proceedings.

As regards the origins of its activity, such activities of the LAAFS have to be mentioned as the elaboration of a conception for granting subsidies for agriculture; the promotion of development of regions, especially Latgale region – based on the Viļāni Selection and Research Farm and the Viļāni Livestock Research Farm, the Agricultural Science Centre of Latgale was established; the elaboration and acceptance of the Statute of Scientific and Research State Organisations based on the law "On Scientific Activity"; participation in the elaboration of an agricultural development conception; the elaboration of amendments to the agricultural legislation, including the elaboration of a draft of the Land Cadastre Law; the popularisation of scientific findings and the organisation of training in modern management for specialists in forestry – an innovation was the exhibition with demonstrations "Vecauce 95", which was followed by other regional exhibitions in Priekuļi and Viļāni; the provision of social security for senior scientists – researchers were elected as state emeritus scientists having financial support; and the education of new scientists by designing master and doctoral study programmes for LLU and by cooperating with universities abroad.

Thus, since its origins, the LAAFS performed a coordinating role in scientific activity in the sector of agriculture and forestry as well as elaborated and introduced a model integrating academic education and science.

What is the performance of the LAAFS and its contribution to agricultural science in Latvia now, when 20 years have passed since the establishment of the academy? In short, the LAAFS continues executing the tasks set initially, only in the spirit of the 21st century.

The LAAFS presently consists of five departments: Agricultural Sciences, Agricultural Economics, Forest Sciences, Engineering Sciences, and Food and Veterinary Sciences.

The largest departments are Department of Engineering Sciences and Department of Agricultural Sciences.

Table 2

The number of LAAFS full members by department in 2013 [3]

Department of Agricultural Sciences	Department of Agricultural Economics	Department of Food and Veterinary Sciences	Department of Engineering Sciences	Department of Forestry Sciences
26	21	25	27	18

Fig.1. Cooperation partners of the LAAFS.

It is noteworthy that the heads of the departments are experienced university professors, former or present deans of the faculties of LLU, while the present rector of LLU, Dr.sc.ing. Juris Skujāns, is the vice-president of the LAAFS. It is still specific that science is mainly based on universities, and a developed science increasingly becomes the main distinctive feature of any modern and sustainable university.

Cooperation with the Ministry of Agriculture of the Republic of Latvia and the Latvian Academy of Sciences has always been important to the LAAFS. Since 2006, this cooperation is supported by the letter of intent which is resigned in the beginning of every year and envisages joint voluntary efforts in: elaborating documents that integrate education, science, and practice, conducting joint research in the fields of agriculture, rural development, and forestry science, holding joint conferences and other activities, popularising scientific achievements, exchanging information among scientific structures, agricultural organisations, and specialists, promoting international scientific cooperation, etc.

A letter of intent among the Ministry of Agriculture of the Republic of Latvia, the Latvian Academy of Sciences, and the Latvian Academy of Agricultural and Forestry Sciences was signed in 2013 for already the eighth time (Fig. 1).

Since 2006, within the scope of the letter of intent, the LAAFS provided, for instance, recommendations to policy makers, participated in the Union of European Academies for Science Applied to Agriculture, Food and Nature (www.euracadagri.com), including performing the duties of presidency of the Union for the period 2008–2010, holding two conferences for the Union in Latvia (in 2008 and 2009), as well as publishing a collection of research papers entitled "Renewable Energy Resources, Production and Technologies" (editors Cristian Hera, Volker Hoffmann, Baiba Rivza), participated in annual meetings of the European Agricultural Research Initiative (EURAGRI: http://www.euragri.org) and in the Standing Committee on Agricultural Research, thus expressing views on essential issues in the fields represented by the LAAFS, took part in congresses of the Nordic Association of Agricultural Scientists and engaged in activities held by Latvia's department of this association, evaluated papers submitted to contests, including the contest "Sējējs" in the section "Science for Rural Development" (during the

recent years – "The New Scientist for Agriculture and Rural Development"), and participated in elaborating a draft of the Traditional Cultural Heritage Law.

Along with it, the LAAFS sets annual research priorities in agricultural science and also implements research projects, and among the most recent ones are: the Nordplus Adult Programme Committee's project "Entrepreneurship and the Cultural Heritage for Women" in the period 2012–2014, and the project funded by the European Social Fund "Consolidation of the Capacities of the Latvian Academy of Sciences and the Latvian Academy of Agricultural and Forestry Sciences and the Elaboration of International Project Proposals" in the period 2011–2013.

To establish closer cooperation with farmers' organisations and representatives of farmers, the LAAFS was admitted to the Latvian Agricultural Organization Cooperation *Council (LOSP)* on 15 February 2012. It is also necessary to effectively implement future development scenarios that are closely associated with activities of scientists of the sector.

The following key future objectives in the sector and also in the activity of the LAAFS may be mentioned: increasing yields and productivity – presently, for instance, the domestic supply of apples meets only about 50% of the market demand, and the yield of potatoes has to be doubled or even tripled; supply of healthy food – the "green economy" has to be developed by fully exploiting the advantages of Latvian rural resources, compared with many other regions, as products of organic farming as well as the prospects for food production and sales, in general, are great; developing innovative solutions – in relation to both production and various ways of sales; in general, innovative entrepreneurship has to be fostered; cooperation between scientists and entrepreneurs and the public – hopes here, in Latvia, are associated with the national research programme "Sustainable Use of Local Resources".

A very important objective of the LAAFS is to assist Latvian farmers to achieve a fair agricultural financial support policy in the European Union for the next programming period from 2014 to 2020. The first success has already been gained owing to a joint declaration made by Baltic agricultural scientific organisations, including the LAAFS, and agricultural universities regarding making such a fair policy.

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Table of contents
International Scientific Conference
ACADEMIC AGRICULTURAL SCIENCE IN LATVIA – 150