LAMMC

LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY

2021

ANNUAL REPORT

LITHUANIAN RESEARCH CENTRE

FOR AGRICULTURE AND FORESTRY

CONTENTS

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DIRECTOR'S FOREWORD

World history will refer to 2021 as the year when people learnt how to function during the pandemic. Although the virus is yet to cease to exist, the vaccines created by scientists allowed us to return to the almost regular rhythm with newly found motivation. It is especially evident in the annual report of the LAMMC activities.

In 2021, the publication rate stayed high and, consequently, 147 articles were published in the journals indexed in the *Clarivate Analytics Web of Science* database (a 20% increase compared to 2020). Over 70% of research papers were published in Q1/Q2 journals, which signified that the bulk of the research conducted by our scientists was published in the journals with the number of citing articles higher than average in the respective field of science. This will undeniably enhance the awareness of our work results in the international community.

Last year we successfully strengthened the international cooperation by participating in the joint projects with foreign research institutions, specifically in "Horizon 2020" programme. As many as six new projects of the EJP SOIL programme were launched, as well as the new H2020 project "A Holistic Fire Management Ecosystem for Prevention, Detection and Restoration of Environmental Disasters" (DRYADS), in which 46 partners participate with the overall budget of 22.9 million euro. Participation in these projects not only allows the LAMMC to acquire new experiences, but also capacitates entering inter-institutional networks that can lead to further cooperation.

The year 2021 was exceptionally successful for LAMMC plant breeders: 14 new plant varieties were registered. Two winter wheat varieties have distinguished qualities, they synthesise amylopectin (without amylose) starch. Furthermore, oat, field pea, red fescue, smooth brome-grass, narrow-leaved lupin, gherkin, onion, and strawberry varieties were registered. We anticipate that the new plant varieties will find their way into farming fields since they were created here in Lithuania and, as a result, these varieties are well adapted to the local farming conditions.

I would like to congratulate the members of our LAMMC community, scientists Dr Giedrė Samuolienė and Dr Kęstutis Armolaitis, on becoming full members of the Lithuanian Academy of Sciences, as well as Dr Monika Toleikienė and Dr Jonas Viškelis on becoming new members of the Young Academy of the Lithuanian Academy of Sciences. I wish them to honourably represent the interests of agricultural science in this institution.

In 2021, LAMMC administration staff faced numerous challenges. Financial, Legal and Personnel, Information Technology, Occupational Safety and Health Services, the Department of Science and Innovation and Department of Communication started their work at the beginning of the year. On 20 October, the LAMMC was reorganised from a budget-funded institution to a public establishment according to the decision of the Government of Lithuania. I would like to thank the administrative staff for their expressed courageous attitude in facing these challenges and for excellent decision making.

In 2022, we will celebrate the 100th anniversary of the establishment of the Plant Breeding Station of Dotnuva. Continuous practice of such a lengthy duration is not a common accomplishment among Lithuanian institutions. I would therefore like to invite the LAMMC community to celebrate our achievements and pursue the mission of an science institution, and to commemorate this significant anniversary.

Director of the Lithuanian Research Centre for Agriculture and Forestry
Dr Gintaras Brazauskas

MAJOR FACTS OF 2021

The Lithuanian Research Centre for Agriculture and Forestry (hereinafter LAMMC) had a total staff of **505**, including **168** researchers and **69** doctoral students.

On 1 January, the structure of the administration unit underwent changes. Dr Vita Tilvikienė, Dr Antanas Ronis, Dr Vidmantas Bendokas, and Dr Marius Aleinikovas were appointed deputy directors. On 20 October, the LAMMC was restructured into a public establishment.

The Centre carried out

40 international and

60 national research projects funded by the Research Council of Lithuania, the Ministry of Agriculture, and the Ministry of Environment;

it fulfilled over

180 contract orders for national and foreign economic entities.

Together with **46** foreign partners, the LAMMC started the implementation of the new programme "A Holistic Fire Management Ecosystem for Prevention, Detection, and Restoration of Environmental Disasters" (DRYADS) as part of the project "Horizon 2020".

In 2021, together with the other members of the association "RTO Lithuania", the LAMMC implemented **3** inter-institutional projects.

Over **70 %** of publications appeared in Q1 and Q2 journals.

12 doctoral students of the LAMMC defended their dissertations.

14 agricultural crop varieties were included in the Lithuanian National List of Plant Varieties and **13** varieties were included in the EU Common Catalogue of Varieties of Agricultural Plant and Vegetable Species.

The Centre implemented **6** long-term institutional research programmes.

LAMMC researchers published **148** scientific publications in the journals indexed in the *Clarivate Analytics Web of Science* (hereinafter CA WoS).

The LAMMC organised **3** international, **4** ational conferences, **1** international workshop, **15** seminars, discussions, field days, and meetings of experience sharing groups.

1. VISION, MISSION, AND VALUES OF THE LAMMC

VISION

A leading state research institute in Lithuania and the North European region, whose activities are based on high-level basic and applied research, acquisition of novel scientific knowledge, development of technologies and innovations, and their transfer and efficient experimental development. An advanced centre of excellence and competence in agricultural, forestry, and food sciences.

MISSION

Generate, garner, and disseminate new scientific know-how geared to the awareness of sustainable land, forest, and environmental resources, their competitive development and use, elaboration of innovative technologies and products to meet the needs of the society.

VALUES

- The spirit of the scientific institution, long-standing traditions, and accountability to the society
- Competence, honesty, and transparency of activities
- Proactiveness, creativity, and continuous improvement
- Community-driven open-mindedness

2. STRATEGIC DIRECTIONS

LAMMC priorities:

- **development of high-level research,**
- **enhancement of internationalisation,**
- **development of doctoral studies,**
- **co-operation between science and business,**
- **community mobilisation,**
- **expansion of public services.**

3. IMPLEMENTATION OF THE OPERATIONAL OBJECTIVES OF THE LAMMC

The goal of the Lithuanian Research Centre for Agriculture and Forestry (LAMMC), as defined in the Statutes of the LAMMC, is to serve the public interest by carrying out long-term scientific research and experimental development that are of interest to the State, society, international cooperation and economic operators.

To achieve the operational goals in 2021, the following objectives were defined:

1) developing high-level scientific knowledge to address national and international economic, environmental, and social challenges;

2) increasing the availability of science-based innovations and solutions to domestic and foreign consumers and the general public;

3) raising the prestige of science and ensuring attractive working conditions in the country's regions.

One of the main objectives of the LAMMC is to generate high-level scientific knowledge to address national and international economic, environmental and social challenges. In 2021, the scientists of the LAMMC published 148 scientific publications in journals referenced in the Clarivate Analytics Web of Science (CA WoS) database and with a citation index (IF), 73% of these publications appeared in high-level international publications (Q1 and Q2). The short-term goal is to achieve a minimum of one scientific publication per researcher and a gradual improvement in the quality of scientific publications.

The development of new, innovative, research-based products and technologies is an ongoing activity of the LAMMC. In 2022, plant breeding in Lithuania celebrates its centenary. In the course of hundred years, agricultural plant varieties have been developed that are both nationally and internationally competitive. During the reporting period, seven plant varieties developed by the LAMMC underwent international expertise in specialised European centres and one application was filed with the European Patent Office. It is likely that the LAMMC becoming a public establishment will further strengthen the development of these activities and encourage researchers not only to develop more innovative products, but also to successfully commercialise them.

Production of high-level scientific knowledge is directly linked to competitive funding and implementation of high-level national and international R&D and other projects. In 2021, LAMMC researchers submitted 76 R&D project proposals worth more than 10.4 million euro. The project success rate is close to 25%. In our view, this is a good achievement, but in order to ensure the successful continuation of the activities of the LAMMC, preparation and submission of more applications to attract competitive funding will be encouraged.

The success of each institution is directly linked to attracting new enterprising researchers. Currently, there are 69 doctoral students at the LAMMC, but this number is likely to increase as the opportunity to apply for the competitive PhD programme funded by the Research Council of Lithuania becomes available. Development of the internationalisation of doctoral studies is also foreseen. In 2021, nine doctoral students from foreign countries studying at the LAMMC, with an increasing number of both English-language and publication-based PhD dissertations. Not only does it facilitate joining international scientific networks, but also enhances the visibility of LAMMC scientists in the international arena.

Objective 1: developing high-level scientific knowledge to address national and international economic, environmental and social challenges.

Measures of the implementation of the operational plan	Criteria of the evaluation of the implementation of the operational plan	Indicators	
		Results of 2021	Results of the 2022 plan
Conducting high-level fundamental and applied research	Scientific publications in journals referenced in the *CA WoS* database and with an index of citation (IF), number	148	160
	Of which publications in Q1-Q2 journals, number	108	120
	Publications with participation of foreign institutions and/or businesses, number	58	65
	Research monograph (at least eight author's sheets) or part(s) of a research monograph (at least 8 author's sheets) published by an internationally recognised scientific publishing house, number	9	10
	Number of research traineeships	17	20

Development of new, innovative, research-based products and technologies	Number of plant varieties that underwent international examination in specialised European centres and/or the number of new species of organisms that underwent international examination	7	8
	The number of patent applications filed with the European Patent Office, the US Patent and Trademark Office, or the Japan Patent Office (by registration certificate)	1	2
Implementation of high-level national and international R&D and other projects	Number of project applications	76	80
	Funding of project applications, million euro	10,4	11,0
	Funds generated by R&D projects, million euro	2,5	2,7
Conducting high-level international doctoral studies	Number of doctoral students	69	71
	Number of doctoral theses defended	12	14
	Number of dissertations in English	4	6
	Number of publication-based dissertations	3	5
	Number of foreign doctoral students	9	9

The key to a country's growth is science-based decision-making in the public and private sectors. In order to strengthen innovation at the national and international level, the LAMMC focuses its activities not only on the implementation of scientific projects and innovation design, but also on their direct implementation and active dissemination of information. In 2021, researchers completed 177 orders from businesses worth 1.8 million euro.

For many years, scientists of the LAMMC have been actively participating in national working groups: they are members of expert groups for the evaluation of projects and national strategic documents, and in recent years their contribution to the activities of international working groups and expert groups submitting proposals to the European Commission has increased significantly. Researchers actively share their scientific knowledge at national and international conferences.

In 2021, due to the constraints prevailing at the time of the COVID-19 pandemic, the number of national events was slightly lower, but it is expected that in 2022 the number of national events will be the same as before. The number of international events increased significantly due to a greater number of international projects organised. At least ten international scientific events are expected to be organised in 2022.

To reinforce the credibility of scientists and the importance of research, there a strong emphasis is placed on the dissemination of information on social networks (Facebook, LinkedIn, and Twitter).

Objective 2: increasing the availability of science-based innovations and solutions to domestic and foreign consumers and the general public

Measures of the implementation of the operational plan	Criteria of the evaluation of the implementation of the operational plan	Indicators	
		2021	2022
Experimental development and innovation	Number of contracts with economic entities	188	190
	Sums of money received from contracts with economic entities, million euro	1,8	2,0
	Number of licensing agreements	22	23
	Sum of money received from licensing agreements, thousand euro	302	310

Developing and presenting science-based recommendations to decision-makers	Number of experts (in national and international groups)	59	60
Disseminating new scientific knowledge to the research community and target groups	Number of presentations at international conferences	73	73
	Number of public presentations (national seminars, field days, exhibitions)	10	20
	Number of national conferences organised	4	4
	Number of international events (conferences, exhibitions, international seminars, courses, briefings) organised	9	9
Dissemination of new scientific knowledge and innovation to the wider public	Number of website visitors	49 931	55 000
	Number of visitors to the *LinkedIn* social network	424	500
	Number of visitors to the *Twitter* social network	65	100
	Number of visitors to the *Facebook* social network	1 895	2000

The LAMMC is increasingly contributing to the implementation of the Green Deal strategy of the European Commission and conducts its activities in a sustainable and resource-efficient manner. A strong emphasis is placed on ensuring Green Procurement, which aims at procuring goods, services, or activities with the lowest possible environmental impact at one, several or all stages of the life cycle of a good, service, or activity. Already in 2021, some public procurement was recognised as green, and in 2022 the target will be at least 50% of the value of procurement.

In addition, the LAMMC also contributes to the implementation of the national regional policy, which has a differentiated impact on the socio-economic development of the regions, with the aim of reducing their socio-economic exclusion and inequalities of development within the regions themselves, and promoting balanced and sustainable development throughout the territory of the whole country. The aim is to ensure salary progression and to raise the qualification of the staff by encouraging participation not only in scientific events, but also in generic competence development activities and by creating conditions for students to pursue their studies with flexible working hours. However, there is a lack of objective information on employees' job satisfaction, which is why surveys to assess employees' emotional well-being are planned for 2022, which will not only help to provide more information on the effectiveness of various management measures in place, but will also help to improve work processes.

Objective 3: raising the prestige of science and ensuring attractive working conditions in the country's regions

Measures of the implementation of the operational plan	Criteria of the evaluation of the implementation of the operational plan	Indicators	
		2021	2022
Application of green technologies in the activities of the LAMMC	Green procurement as a share of total procurement, %	10	50
	Proportion of electronic files prepared for archiving as a percentage of total files, %	27	50
Creating favourable working conditions at the LAMMC	Increase in average salaries of researchers in per cent, no less than	12	10
	Percentage of staff participating in professional development activities per year, no less than	15	25

In 2021, performance of the LAMMC was good, but there is potential for improvement in 2022 and beyond. The main planned indicators are set out in the tables; targeted expenditure will be planned to achieve them. New research is planned, the internship fund will be continued, and the participation of researchers in scientific and expert activities, as well as in education and in raising public awareness will be encouraged.

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4. HUMAN RESOURCES

4.1. THE RESEARCH BOARD

The Research Board is a collegial management body of the LAMMC. The Board consists of 15 members with a term of service of five years (elected on 24 September).

The Board sets key directions for the research activities, approves the activity plan of the LAMMC, which is submitted by the director, and annual reports. The Board sets forth qualification requirements for researchers and other employees and procedures for their performance assessment and employment, approves various documents related to research activities, and performs other activities laid out in the statute of the LAMMC.

▲ Members of the Research Board

Members of the Research Board

◀ **Prof. Dr habil. Zenonas Dabkevičius**
Advisor to the Director, Chief Researcher, Lithuanian Research Centre for Agriculture and Forestry, Chair of the Research Board

Dr. Giedrė Samuolienė
Head of the Laboratory of Plant Physiology, Chief Researcher, Institute of Horticulture, Lithuanian Research Centre for Agriculture and Forestry, Deputy Chairperson of the Research Board

Dr Povilas Žemaitis
Senior Researcher, Department of Silviculture and Ecology, Institute of Forestry, Lithuanian Research Centre for Agriculture and Forestry, Deputy Chairperson of the Research Board

Dr Audronė Mankevičienė
Chief Researcher, Department of Plant Pathology and Protection, Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry, Secretary of the Research Board

Dr Marius Aleinikovas
Deputy Director for Institute of Forestry Activities

Dr Vidmantas Bendokas
Deputy Director for Institute of Horticulture Activities

Dr Gintaras Brazauskas
Director, Lithuanian Research Centre for Agriculture and Forestry, Chief Researcher, Laboratory of Genetics and Physiology, Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry

Dr Zita Duchovskienė
Head of Technology and Innovation Division, Ministry of Education, Science and Sport of the Republic of Lithuania

Dr Saulius Jasius
Senior Advisor, Sustainable Agricultural Production Policy Group, Ministry of Agriculture of the Republic of Lithuania

Dr Žydrė Kadžiulienė
Chief Researcher, Department of Plant Nutrition and Agroecology, Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry

Dr Nerijus Kupstaitis
Head of the Forest Policy Group, Ministry of Environment of the Republic of Lithuania

Dr Alfas Pliūra
Chief Researcher, Department of Forest Genetics and Tree Breeding, Institute of Forestry, Lithuanian Research Centre for Agriculture and Forestry

Rolandas Pridotkas
Director of UAB "Rūta"

Dr Alma Valiuškaitė
Head of the Laboratory of Plant Protection, Senior Researcher, Institute of Horticulture, Lithuanian Research Centre for Agriculture and Forestry

Prof. Dr habil. Rimantas Velička
Professor, Institute of Agroecosystems and Soil Sciences, Agriculture Academy, Vytautas Magnus University

4.2. THE LABOUR COUNCIL

The Labour Council of the LAMMC is a collegial body representing its employees. It defends the professional, labour, economic, and social rights of the employees of the LAMMC and its branches and represents their interests. It is elected for a three-year term of service. The Labour Council consists of nine members (elected in 2020).

Members of the Labour Council

◀ **Ramunė Kvedarienė**
Senior Economist, Financial Service, Chairperson of the Labour Council

Laura Ledeniova
Senior Personnel Specialist, Legal and Personnel Service, Deputy Chair of the Labour Council

Agnė Jankauskienė
Head of the Legal and Personnel Service, Secretary of the Labour Council

Dr Danguolė Juškevičienė
Researcher, Institute of Horticulture

Dr Renaldas Žydelis
Researcher, Institute of Agriculture

Assoc. Prof. Dr Jonas Volungevičius
Senior Researcher, Institute of Agriculture

Dr Rita Asakavičiūtė
Senior Researcher, Vokė Branch, Institute of Agriculture

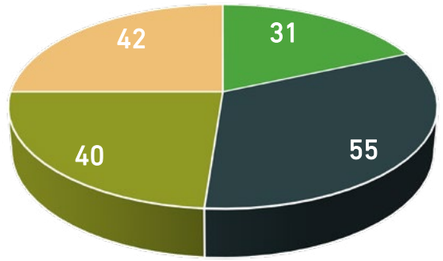
Viktorija Gecaitė
Junior Researcher, Joniškėlis Experimental Station, Institute of Agriculture

Kęstutis Žemantauskas
Agricultural Advisor, Agrochemical Research Laboratory, Institute of Agriculture

4.3. PERSONNEL

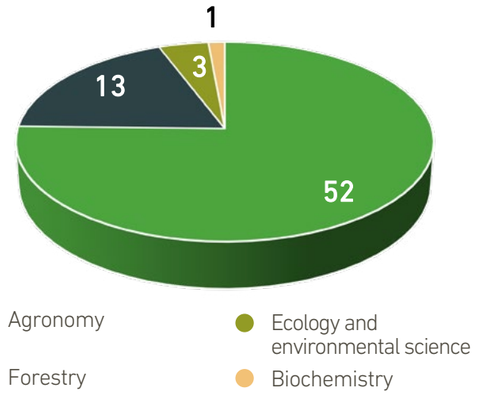
As of 1 December 2021, the LAMMC employed a total staff of 505, of which researchers accounted for 33%, specialists and other employees 42%, laboratory assistants and technicians 23%, and administration 2%.

Among researchers, head researchers made up 18%, senior researchers 33%, researchers 24%, and junior researchers 25% (*Figure 1*).



▲ **Figure 1.** Number of employees by position in the LAMMC

In 2021, LAMMC had 69 doctoral students in the fields of agronomy, forestry, ecology and environment, and biochemistry sciences (*Figure 2*).



▲ **Figure 2.** Distribution of doctoral students across the branch divisions of the LAMMC

The majority of PhD students were studying in the field of agronomy and conducted their research at the Institute of Agriculture.

5. DOCTORAL STUDIES

In 2019, based on the decree of the minister of Education, Science and Sports of the Republic of Lithuania, the LAMMC was granted the right for doctoral studies in four fields of science:

- **Agronomy**
  (jointly with Vytautas Magnus University),
- **Forestry**
  (jointly with Vytautas Magnus University),
- **Ecology and environmental science**
  (jointly with Vytautas Magnus University),
- **Biochemistry**
  (jointly with Vytautas Magnus University and Lithuanian University of Health Sciences).

The four-year doctoral programmes offered by the LAMMC conform to the problematics of contemporary agriculture and forestry. The latest methods are used in research; experienced scientists lead and supervise research activities and studies.

LAMMC LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY

VYTAUTAS MAGNUS UNIVERSITY MCMXXII

LITHUANIAN UNIVERSITY OF HEALTH SCIENCES

5.1. DOCTORAL STUDENTS ENROLLED IN 2021 AND THEIR RESEARCH TOPICS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Agricultural Sciences, Agronomy (A 001)

1. **Ahmed Hosney.** Synthesis and application of sustainable, eco-friendly products with antimicrobial activity. Supervisor Dr Karolina Barčauskaitė.

2. **Aistis Petruškevičius.** Modeling and optimisation of biorefining processes for fruits and vegetables and their by-products. Supervisor Prof. Dr Pranas Viškelis.

3. **Ayodeji Samuel Olorunfemi.** Adaptivity to abiotic stress and biomass formation under unfavourable conditions in perennial grasses. Supervisor Dr Kristina Jaškūnė.

4. **Augustina Kolytaitė.** The interaction of brown rot blossom blight pathogens with naturally distributed bacterial antagonists. Supervisor Dr Birutė Frercks.

5. **Aurimas Sabeckis.** The factors affecting the occurrence, severity and distribution of diseases caused by *Microdochium* spp. pathogens in winter wheat. Supervisor Dr Roma Semaškienė.

6. **Gediminas Čepurna.** Management of multispecies crop production systems for ecological impact and environmental sustainability. Supervisor Dr Lina Šarūnaitė.

7. **Justina Kaziūnienė.** Selection of competitive and efficient *Rhizobium* spp. strains for different *Pisum sativum* genotypes. Supervisor Dr Skaidrė Supronienė.

8. **Raminta Antanynienė.** Genetic diversity of brown rot blossom blight pathogens in *Prunus* spp. plant species. Supervisor Dr Birutė Frercks

9. **Sana Ullah.** Stress caused by heavy metals and effects on plant growth and quality. Supervisor Dr Karolina Barčauskaitė.

10. **Shayan Syed.** Development and evaluation of spring wheat breeding material for adaptability to biotic stresses. Supervisor Dr Andri Gorash.

11. **Shervin Hadian.** Population structure and diversity of endophytic bacteria from *Artemisia* spp. plants and their potential in sustainable agriculture. Supervisor Dr Skaidrė Supronienė.

Agricultural Sciences, Forestry (A 004)

1. **Egidijus Vigricas.** Emissions of greenhouse gasses from forests organic soils. Supervisor Dr Kęstutis Armolaitis.

2. **Greta Striganavičiūtė.** Assessment of the suitability of *Betulaceae* and *Salicaceae* family trees for the environmental protection against persistent organic pollutants, using innovative biotechnological tools. Supervisor Dr Vaida Sirgedaitė-Šėžienė.

3. **Valentinas Černiauskas.** Biomonitoring of air pollution in the context of climate change. Supervisor Dr Valda Araminienė.

5.2. DOCTORAL DISSERTATIONS DEFENDED IN 2021

Agricultural Sciences, Agronomy (A 001)

1. **Andrius Šarka.** Mineral nitrogen variability in histosols. Supervisor Prof. Dr habil. Gediminas Staugaitis.

2. **Armina Morkeliūnė.** Genetic diversity of *Colletotrichum* spp., harmfulness and control of strawberry anthracnose. Supervisor Dr Alma Valiuškaitė, scientific advisor Dr Neringa Rasiukevičiūtė.

3. **Auksė Burakova.** Biogenic elements found in plants, soil, and water when using organic fertilisers. Supervisor Dr Eugenija Bakšienė, scientific advisor Dr Almantas Ražukas.

4. **Giedrius Petrauskas.** Genetic diversity of the autochthonous red clover (*Trifolium pratense* L.) populations. Supervisors Dr Vilma Kemešytė and Dr Kristina Jaškūnė, scientific advisor Dr Gražina Statkevičiūtė.

5. **Kristina Laužikė.** Optimisation of apple tree biological potential using technological tools. Supervisor Dr Giedrė Samuolienė, scientific advisor Dr Nobertas Uselis.

6. **Lina Dėnė.** Adaptation of plant extracts for biological control of strawberry (*Fragaria ananassa* Duch.) pests. Supervisor Dr Alma Valiuškaitė, scientific advisors Prof. Dr Pranas Viškelis and Dr Edita Dambrauskienė (till 2021).

7. **Linas Jurgutis.** The effect of industry-derived organic matter on soil properties. Supervisor Dr Alvyra Šlepetienė, scientific advisor Assoc. Prof. Dr Jonas Volungevičius.

8. **Mohammad Almogdad.** The occurrence, harmfulness and control of insect pest species in broad bean (*Vicia faba* Linn.). Supervisor Dr Roma Semaškienė.

9. **Tomas Žukaitis.** The influence of different intensity tillage on sustainability of organic carbon in clay loam *Cambisol*. Supervisor Dr Inga Liaudanskienė.

10. **Viktorija Gecaitė.** Optimisation of plant nutrition by growing binary crops in organic agrosystem. Supervisor Dr Aušra Arlauskienė, scientific advisor Dr Žydrė Kadžiulienė.

Agricultural Sciences, Forestry (A 004)

1. **Asta Doftartė.** Forestry sustainability and factors affecting it in small-scale private forestry. Supervisor Dr Diana Lukminė.

Biomedical Sciences, Ecology and Environmental Science (N 012)

1. **Sigitas Tamošaitis.** Processes of natural hybridisation in native species of *Alnus* and *Ulmus* genus. Supervisor Dr Virgilijus Baliuckas.

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6. COLLABORATION

In carrying out research and experimental development (R&D) activities, the Lithuanian Research Centre for Agriculture and Forestry co-operates with national and foreign scientific and business institutions. In 2021, the LAMMC successfully collaborated with the Lithuanian Energy Institute (LEI), the Center for Physical Sciences and Technology (FTMC), and the public institution "Science and Technology Park of the Institute of Physics" in the implementation of three projects:

1. "Plant nutrients recovery using secondary raw materials" (NUTREC). Project coordinators: Dr Karolina Barčauskaitė (LAMMC), Dr Marius Urbonavičius (LEI) Dr Ilja Ignatjev (FTMC). 8 February–8 December 2021.
2. "New methods of extracting valuable substances from algae grown in complex multitrophic aquaculture" (ExtraIMTA). Project coordinators: Dr Arūnas Stirkė (FTMC), Dr Eugenija Bakšienė (LAMMC), Dr Liutauras Marcinauskas (LEI). 8 February–8 December 2021.
3. "Development of biodegradable biofuel cells" (BioDegra). Project coordinators: Prof. Dr habil. Arūnas Ramanavičius (FTMC), Dr Monika Vilkienė (LAMMC), Dr Nerijus Striūgas (LEI). 8 February–8 December 2021.

In 2021, new co-operation relations were established with the public institution "AgriFood Lithuania DIH". The goal of this co-operation is to unite the representatives of associations and the governmental sector in the fields of science and business to create a digital innovation centre in the sector of agri-food. Furthermore, the LAMMC started co-operation with Kaunas Forestry and Environmental Engineering University of Applied Sciences (KMAIK) to educate the young generation, to raise the qualifications of the workers, to collaborate in scientific research, and to develop a practical and cultural collaboration.

Membership in international organizations is crucial to be active in international research. The LAMMC is a member of the renowned international organisations:

- **European Plant Science Organization (EPSO)**
- **European Forest Institute (EFI)**
- **Global Research Alliance on Agricultural Greenhouse Gases**
- **European Vegetable Research Institutes Network (EUVRIN)**
- **International Society for Horticultural Science (ISHS)**
- **European Fruit Research Institutes Network (EUFRIN)**
- **International Union of Food, Science, and Technology (IUFoST)**
- **International Union of Forest Research Organizations (IUFRO)**
- **European Association for Research on Plant Breeding (EUCARPIA)**

7. INNOVATIONS

7.1. INNOVATIVE PRODUCTS

In 2021, a cooperation agreement was signed with Nordic Berry Ltd to create new and innovative products as well as zero waste recycling technologies. One of the collaboration areas is zero waste recycling of quince and the use of the secondary products of the recycling for the ingredients of the cosmetic products of a high additional value.

In collaboration with the private enterprise "Morkūnas", we are creating extrusion products to optimise the conditions and technologies of drying of various vegetables. The prototypes of vegetable rolls and the experimental batch for the creation of new products were created.

▲ Lyophilized pumpkins

The LAMMC, together with the small partnership Aralika, is implementing an R&D project "The evaluation of the biochemical composition of the morphological parts of the plant *Aralia cordata* and the evaluation of its physical, chemical, and antioxidant characteristics for the creation of a functional food product". The goal is to popularise this plant in the Lithuanian and foreign markets by making various products that contain various components of the plant. Various drinks (juice, sap, etc.) are to be developed and produced using *Aralia cordata*, such as protein shakes for athletes and some cosmetic products (hydrolats and an essential oil).

▲ Presentation of a berry and fruit juice drink with *Aralia* to basketball players

7.2. ACTIVITIES, PROJECTS OF CONSTRUCTION AND HEATING MODERNIZATION

In 2021, LAMMC started implementing the project **"Strengthening of the technology transfer and commercialization of the knowledge created by Lithuanian research Centre for Agriculture and Forestry"**, funded by European Structural and Investment Funds and supervised by Dr Vita Tilvikienė. In order to achieve a more active collaboration between science and business in developing innovative products of agriculture, food and forestry sectors, the LAMMC started applying entrepreneurial principles in commercialisation and technology transfer during the project implemented from 2021 to 2023.

Innovations have been introduced not only in commercialisation but also in modernisation of buildings. On 7 January, the LAMMC signed three contracts for modernisation. After the modernisation of the buildings of the LAMMC, the consumption of energy will decrease by 600 MWh, and the emission of greenhouse gas by 105 t CO_2 eq.

Two solar power plant development projects were implemented. **A solar power plant of the Lithuanian Research Centre for Agriculture and Forestry** was launched in Akademija, Kėdainiai district, on 18 October 2021. The allowed generated power for the plant is 99.75 kW, which should provide a sufficient supply of electricity in the laboratory building of the LAMMC at 2 Stoties St., Akademija. Another solar power plant, of 510 kW, started working in Babtai, Kaunas district, in November. It should supply part of electric energy needed for the scientific departments of the LAMMC Institute of Horticulture.

▲ Solar power plant in Akademija, Kėdainiai district

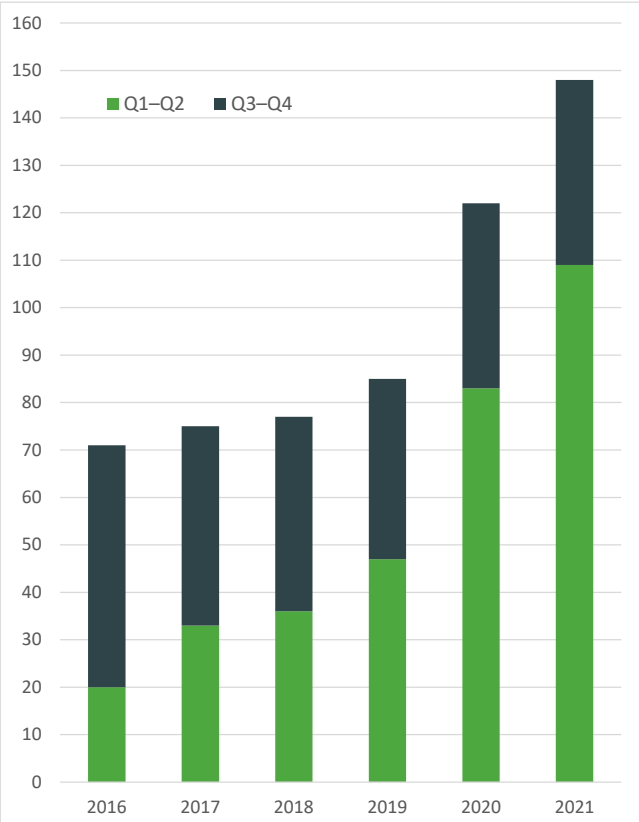
8. RESEARCH AND DEVELOPMENT

8.1. SCIENTIFIC PUBLICATIONS OF 2021

The year 2021 was the most productive in the entire history of the LAMMC, with **148** scientific publications published in the journals with an impact factor (IF) indexed in the CA WoS database. The highest IF of the scientific journals, which published research data obtained by the LAMMC researchers and colleagues from research and study institutions of other countries, was **20,372** (2020–2021).

In 2021, LAMMC researchers, in publishing their research results, paid considerable attention not only to the number of publications, but also to the quality of journals in which research was presented. More than 70% of publications appeared in Q1 and Q2 quartile journals, reflecting both the activeness of researchers and the high level of research and the international recognition of their results (*Figure 3*).

In addition, in 2021, the researchers of the LAMMC wrote and published **4** sections in monographs published by the internationally recognised publishers, also books, textbooks or their sections, **19** articles in peer-reviewed periodicals, and over **50** popular science articles.



▲ **Figure 3.** Number of publications per quartile

8.2. LONG-TERM RESEARCH PROGRAMMES

The LAMMC participated in six long-term R&D programmes (2017–2021). The results of the ongoing long-term research programmes for the year 2021 are presented below.

Biopotential and quality of plants for multifunctional use

Leader Dr Žydrė Kadžiulienė

The goal of the recent programme was to develop new technologies, to study traditional and new crops, and to explore their applications and combinations of different agronomic measures for higher and safer productivity, taking into the account the potential effects of climate change. In 2021, which was the last year of the final stage of the programme, new results were obtained from studying these topics: the optimisation of plant nutrition in binary crops in the organic agro-ecosystem; the productivity and stability of crop rotation in technological systems of different intensities; the effect of the sewage sludge compost on the properties of the biomass of the grasses; the use of local plants in the formation of special-purpose flowering meadows; the formation of the biomass of *Artemisia* plant. Research on the topics of strengthening the multi-functionality of agroecosystems with binary crops, the efficiency of legume-based fertilisation biomass for organic agro-ecosystem, the changes in the chemical composition and the technological properties of winter wheat grains using organic liquid fertilisers, the improvement of productivity and quality of fibre hemp and other plants is being continued. The results of the research programme were presented to the scientific community and other subjects who took

▲ Experiment of the third year use of grassland

part in agricultural economic activities. Eighteen articles were published in scientific journals with a citation index, 15 presentations were made at international and national conferences; the practical aspects of research were disseminated in seminars, field days and popular science articles.

▲ Winter wheat and white clover crop

Sustainable forestry and global changes

Leader Dr Marius Aleinikovas

In the recent years, the forest sector in Lithuania has been experiencing the impact of many global changes such as the climate change, the noticeable rise in the frequency of the natural disasters, the change in the condition of the trees, the dwindling of biodiversity, etc. **The aim of the programme** was to obtain and systematise the new scientific knowledge necessary for the development of sustainable forest management in the context of global natural, economic and social changes and to prepare recommendations for applying this knowledge in practice.

In 2021, the growth of silver birch plantations was studied where the conditions of the implantation were of different density and of different shapes (square or rectangle). The optimal density of 3000 units/ha was estimated the dependence of productivity on the rectangular index.

The stems of the Scots pine and Norway spruce that were grown at different densities were evaluated. The damage, curvature, and branchiness of the stems were measured. It was estimated that the average diameter of the branch between the thinnest (5000 units ha^{-1}) and the densest (600 units ha^{-1}) variant at the pine forests of the 0–6 m height stems differed 1.5–1.6 times; for the spruce, the difference was 1.3–1.5 times, or 0.5 cm. The observation showed that when the density of the forest stand decreased the diameter of the branch increased.

▲ Reforestation of a logging site

In 2021, ground vegetation was evaluated after clearcutting. The results revealed that the amount of ground vegetation of the previous clear-cut area, where a new pine forest (the forest site type was Nb) was forming, had increased after 8–10 years after the clear felling. When the forest stand had reached the age of 30 years, this index did not change in the essence from the one recorded in a mature forest.

In 2021, a methodology for genetic monitoring was developed for Scots pine, English oak, silver birch, and Norway spruce. The micropropagation technology for the production of the sprouts of the selected tree species that were grown *in vitro*, and their adaptation *ex vitro* were optimised.

The dynamic changes in the communities of fungi and insects, the restoration after clearcutting, and the use of biomass in the ecosystem of a pine forest were evaluated. The damage caused by ungulates to coniferous forests was assessed in order to manage local populations in an all-round way, a new methodology for evaluating the number of boars was tested and adapted accordingly.

Harmful organisms in agro and forest ecosystems

Leader Dr Roma Semaškienė

The aim of the programme is to investigate the peculiarities of behaviour of dominant and newly emerging pests in the agro-forest ecosystems and to develop a scientific basis for managing their destructive effects in a manner that maintains economic benefits without compromising environmental and human safety, biodiversity conservation.

Eleven studies are being continued; three new studies were started in 2021:

1) Determinants and damage caused by *Microdochium* spp. pathogens in winter wheat: the prevalence and species dominance. The aim of this work is to determine the influence of anthropogenic and natural factors on the incidence and damage caused by *M. nivale* and *M. majus*.

▲ Effectiveness of seed treatment against spring mould

2) Mixtures of different cereal genotypes as an alternative to more sustainable crop production. The aim of this study is to determine the intensity of fungal diseases in crops of genetically different wheat mixtures and to assess the benefits of wheat variety mixtures in terms of economic value and sustainable farming.

3) Type A trichothecenes and related problems in winter and multipurpose spring barley grains. The objective is to investigate the potential uses of barley grain and products from different varieties and uses based on criteria for type A trichothecenes and quality indicators.

The results are presented in ten scientific journals indexed in CA WoS database.

▲ **Control of the *Microdochium* pathogen in winter wheat**

Horticulture: agrobiological foundations and technologies

Leader Dr Giedrė Samuolienė

The purpose of this programme is to develop a scientific basis for agrobiological processes of horticultural plants with the aim of increasing the potential of productivity and product quality by applying innovative, environmentally- and resource-friendly technologies.

The main R&D directions are:

1) Expansion of the knowledge specific to the plant physiology and application of agrobiotechnological tools for management of specific aspects of plant growth, development, photosynthesis, and metabolism for higher quality, more valuable and sustainable plant production in controlled environment horticulture.

2) R&D in modern horticulture by selecting rootstock-scion combinations and varieties of horticultural plants, emphasizing the adaptability of rootstocks to agro-climatic conditions and tribal soil degradation. Influence of plant breeding, cultivation systems, and technological tools on plant growth, productivity, yield stability, and fruit quality.

3) Development of innovative growing technologies for greenhouse and outdoor garden plants. Adaptation of environmentally and pathogen-resistant varieties for a sustainable horticulture and supply of production for short food chains. Increasing and preservation of soil biopotential and protection of the environment by reducing environmental pollution using agro-biological and agro-ecological tools.

4) Analysis of chemical composition and technological properties of horticultural plants and created high-value products. Optimisation of horticultural product storage conditions, development and optimisation of waste-free technology processes.

▲ Horticultural experimental fields in Babtai

Productivity and sustainability of agricultural and forest soils

Leader Dr Virginijus Feiza

European Comission documents set out common principles for Soil Thematic Strategy to protect soils across the EU. The document states that each EU member state must take care of the sustainable use of soils on its territory so that their quality and productivity do not deteriorate.

The goal of the programme is to evaluate soil fertility potential in agricultural and forest ecosystems, to develop the factors which affect their degradation, and to choose the measures to maintain soil sustainability, to optimise carbon cycle in the soil, to reduce greenhouse gas emission and plant nutrient losses from the soil in different regions of the country.

The research is focused on three main directions:

1) Productivity improvement and reduction of degradation processes of the soils of morainic and limnoglacial origin.

2) Rational use of natural soil resources, organic and mineral materials of local origin.

3) Evaluation of the productivity potential of agricultural and forest soils.

Due to deeper understanding of the processes taking place in the soil, the scientists of different scientific branches (agriculture, biomedicine, physical science) are involved.

In 2021, the participants of the long-term programme participated in project of EJP SOIL of H2020 Programme, published 24 papers in journals with IF, six papers are currently under revision, 19 popular articles were published in the national press. The researchers participated in national and international conferences with 25 oral presentations. Five recommendations for agriculture and forest practices were issued.

▲ Maize with applied organic fertiliser (right) and with no fertilisation (left)

▲ As the climate is warming up, it is essential to save soil moisture

Genetic determination of the traits of agricultural and forest plants, development of modern cultivars

Leaders: Prof. Dr habil. Vidmantas Stanys, Assoc. Prof. Dr Vytautas Ruzgas

Agricultural and forest plants can provide economic revenue only if competitive lines, varieties, or populations are being used. Natural and agricultural ecosystems are in perpetual fluctuation because of various environmental factors, such as climate change, hydrological regime, pest and pathogen infestation. New techniques and products are constantly being developed for plant cultivation; quality parameters for the plant production are constantly changing in the processing industry. Therefore, the genotypes and population structures of agricultural and forest plants have to be continuously improved and adapted to meet the current economic and environmental needs.

The objective of the programme is to develop molecular markers for abiotic and biotic stress resistance, plant productivity and quality parameters; to create high quality novel breeding material for the development of new commercially successful plant varieties; to identify genotypes of forest plants beneficial for the development of the national economy.

In 2021, the programme further was carried out by the departments of Cereal and Grass Breeding, Laboratory of Genetics and Physiology of the Institute of Agriculture, the Department of Orchard Plant Genetics and Biotechnology of the Institute of Horticulture and the Institute of Forestry. Genetic factors governing plant phenotype and stress response were investigated; new breeding material superior in productivity and quality was created, and new varieties were developed; evaluation of progeny of selected tries, development and assessment of breeding populations was carried out.

The results of 2021 were published in 19 articles in the journals indexed in *Clarivate Analytics Web of Science* database; 11 articles in other scientific journals; 385 new breeding lines developed; six new varieties were submitted for registration, and 14 varieties were registered in the National Variety List.

One-hundred-and-twenty offsprings of the white birch were investigated in three experimental nurseries. The results were presented at three scientific conferences, five professional seminars, and eight articles were published in the professional press.

▲ Tall wheat is back in organic farming

▲ Genetic diversity of pea for the programme of variety development

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8.3. PROJECTS

In 2021, **40** international (*Figure 4*) and **60** national (*Figure 5*) projects were carried out at the LAMMC. In total, over 180 research projects were conducted in 2021 under contracts with Lithuanian and foreign entities.

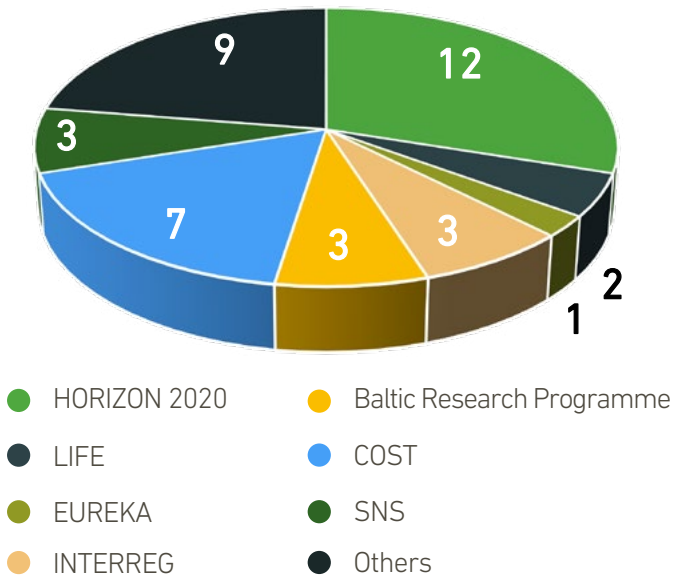

Figure 4. International projects in 2021

Most of the international projects were funded by "Horizon 2020", with nine LIFE projects, seven COST activities, also programmes of EUREKA, INTERREG, Baltic Sea Research, Nordic Forest Research Committee (NFRC) and other projects.

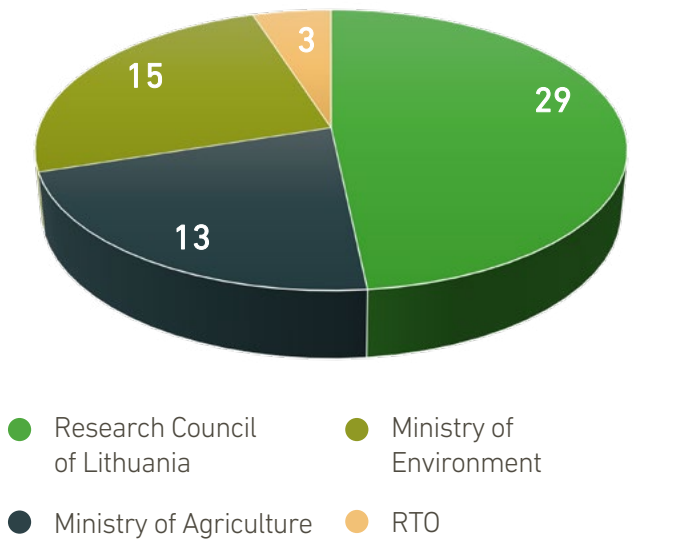

Figure 5. National projects in 2021

National R&D projects funded by the Research Council of Lithuanian, the Ministry of Agriculture and the Ministry of Environment, as well as three projects of the association RTO Lithuania (RTO) were implemented.

A full list of international and national projects is provided in the annexes.

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8.3.1. International projects launched in 2021

In 2021, the LAMMC launched **11** international projects. The descriptions of all international projects launched are given below.

"Horizon 2020" projects

1. A holistic fire management ecosystem for prevention, detection and restoration of environmental disasters (DRYADS).

Project coordinator Dr Vaida Sirgedaitė-Šėžienė, Institute of Forestry. 2021–2025.

To achieve that Europe become the first climate-neutral continent in the world before 2050, goals and targets according to the priorities of the EC were set: to use all possible routes to cut CO_2 emissions, reduce the incidence and extent of forest fires, reduce waste, foster circularity, strengthen industrial symbiosis and boost the ability of the EU to predict and manage environmental disasters. Those are the key vectors in achieving goals of the DRYADS project, which aim to create a Holistic Fire Management Platform for Prevention, Detection and Restoration of Environmental Disasters.

▲ Project participants

2. Mechanisms underlying TRAde-offs between Carbon sequestration, greenhouse gas Emissions and nutrient losses in Soils under conservation agriculture in Europe (TRACE-Soils).

Project coordinator Dr Dalia Feizienė, Institute of Agriculture. 2021–2024.

The aim is to identify the mechanisms of soil carbon sequestration, greenhouse gas emissions, and nutrient losses in agricultural soils. Soil abiotic and biotic predictors will be revised in long-term experiments across a NE-SW pedoclimatic gradient in Europe. Modelling scenarios will be posed. At present, literature analysis is performed. Soil samples

from LTEs of the participants are collected for analysis in different laboratories, including LAMMC.

▲ Measuring CO_2 emissions from soil by studying carbon sequestration

3. Innovative soil management practices across Europe (i-SoMPE).

Project coordinator Dr Lina Šarūnaitė,
Institute of Agriculture. 2021–2022.

The i-SoMPE project has **two main objectives**:

1. Identify and document SMPs across Europe in a broad way and with a focus on innovative farming systems and related innovative SMPs. This first objective, more descriptive, is subdivided in three sub-objectives:

1.1. Technical description of each innovative SMP and its variants.

1.2. Actual application of each practice in Europe (mapping).

1.3. Potential effects on the five goals of the EJP SOIL project (Soil and climate mitigation – soil carbon sequestration, Soil and climate change adaption, Sustainable agricultural production, Environment – ecosystem services, land and soil restoration - soil fertility and soil erosion prevention) and on other goals (pest and disease control).

2. Assessing the potential application of each innovative SMP in Europe, considering technical and environmental constrains as well as socio-economic and cultural barriers.

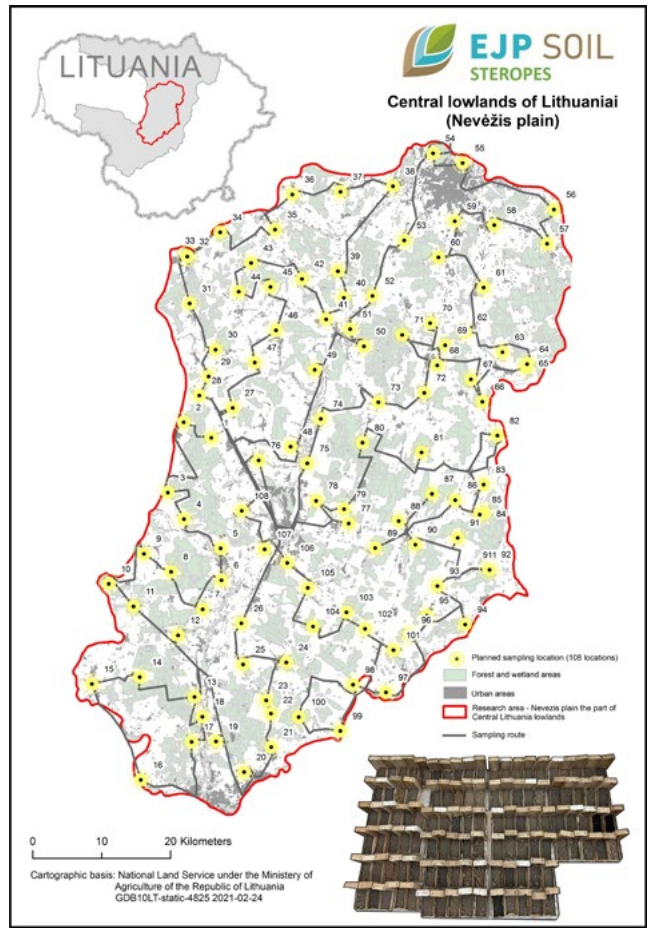
The i-SoMPE proposal is built around one main stocktaking activity and based on a surveying approach for identifying, documenting, and analysing SMPs in each member state.

4. Stimulating novel technologies from earth remote observation to predict European soil carbon (STEROPES).

Project coordinator Dr Renaldas Žydelis,
Institute of Agriculture. 2021–2024.

During the project, the potential for the use of satellite surface imagery to predict soil organic carbon in European regions under different pedoclimatic and agro-ecological conditions will be tested. The first stage will be to analyse the links between satellite imagery ("Sentinel-1,2" and/or others) in areas where ground information on soil organic carbon is known. In the second stage, the factors interfering with the prediction of SOC content in soil will be analysed: soil moisture, granulometric composition, salinity, surface roughness. In areas where reliable predictions of SOC content in soil will not be available from satellite data, other additional methods, i.e., geophysical, will be applied for prediction.

The LAMMC contribution to the project: mapping of the amount of SOC in the soil of the territory of Lithuania, development of the model of soil moisture in the territory of Lithuania or measurements *in situ* will be carried out, information on granulometric composition will be provided.



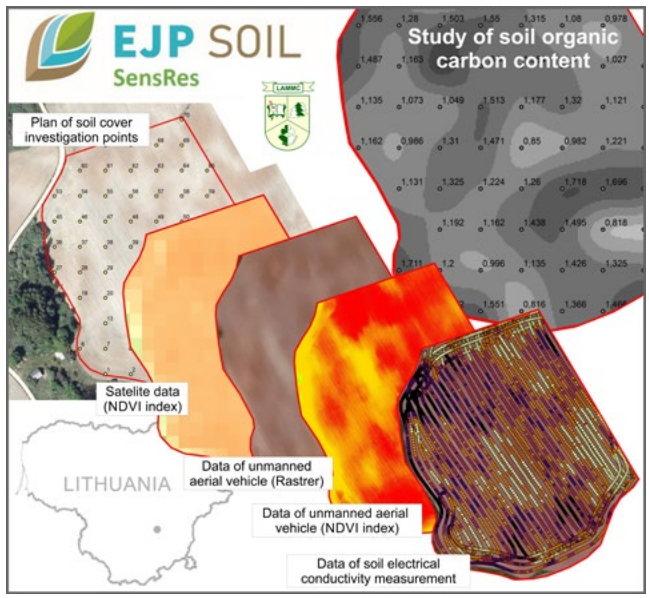
▲ **Figure 6.** The STEROPES methodology

5. Sensor data for downscaling digital soil maps to higher resolutions (SensRes).

Project coordinator Dr Renaldas Žydelis,
Institute of Agriculture. 2021–2024.

During the project, using satellite and unmanned aerial vehicle data, i.e., visual and multispectral imaging as well as electromagnetic induction sensor data, a methodology will be developed for remote detailing of digital soil maps and functionalising them, efforts will also be made to assess chemical and physical properties of soil that are necessary to address practical issues. The ability of the EMI sensor to estimate and calculate the amount of moisture and organic carbon available to plants in the soil for modelling soil erosion processes will be tested. In the territory of Lithuania, the research will be carried out under contrasting soil and agroecological conditions: in fertile soils of clay lowlands and less fertile soils of hilly highlands (five fields).

During the project, the LAMMC will be coordinating data collection (WP1 leader - Data acquisition) between project partners which will include systematic management of already existing data (soil maps, sensor data, etc.) and receiving new data from other project partners.



▲ **Figure 7.** Soil organic carbon quantity analysis

6. Soil organic carbon sequestration potential of agricultural soils in Europe (CarboSeq).

Project coordinator Dr Ieva Mockevičienė,
Institute of Agriculture. 2021–2024.

The aim of the project is to assess the potential for carbon sequestration in Europe. To assess trends in carbon sequestration under different scenarios, carbon sequestration potential will be modelled to assess the impact of different agro-measures at European level. The project will build on ongoing research activities in partner countries, including long-term field trials, soil monitoring data. Different carbon management scenarios will be evaluated using RothC or other models. Maps of the potential for soil organic carbon sequestration, through certain agro-measures, will help to select the most appropriate carbon management measures for Europe's pedoclimatic regions to mitigate climate change.

The project will be carried out in collaboration with the FAO to develop a global map of carbon sequestration potential. The maps will provide clear spatial data on the potential for DOM sequestration over the coming decades to mitigate the effects of climate change in Europe and increase soil fertility and resilience.

▲ Estimation of soil organic carbon

7. Stocktaking for agricultural soil quality and Ecosystem Services Indicators and their Reference values (SIREN).

Project coordinator Dr Dalia Feizienė,
Institute of Agriculture. 2021.

The project is aimed at making an inventory of indicator systems for assessing soil quality and ecosystem services, as currently used by Member States associated in the EJP SOIL.

SIREN will identify and review the national frameworks and chains from soil properties via soil functions to soil ecosystem services and the indicators of soil quality state and functions plus their reference values across pedo-climatic conditions for the main agricultural production systems in the EU. Also, SIREN will identify if these have been translated into policy options and implementation, and into directions and guidance on land management.

SIREN will particularly stocktake the array of reference values for SOC, soil quality, soil biodiversity and degradation risk, the associated target values of indicators, and identify knowledge gaps and development needs.

▲ Visual assessment of soil quality indicators to determine ecosystem functionality

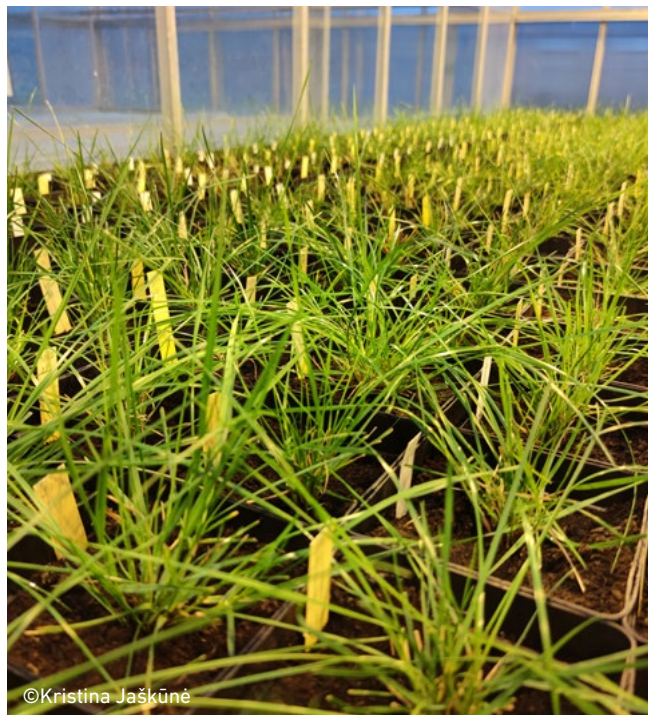
Baltic Research Programme Project

1. Improving adaptability and resilience of perennial ryegrass for safe and sustainable food systems through CRISPR-Cas9 technology (EditGrass4Food).

Project coordinator Dr Kristina Jaškūnė,
Institute of Agriculture. 2021–2024.

The aim of the project is to utilise transcriptomics and functional genomics to increase sustainability in agriculture through improvement of perennial ryegrass with better adaptation to frost and drought for current and future climates. Main objectives:

1. Establish a diverse perennial ryegrass core association panel by utilization of data from ongoing projects,
2. Screen the association panel in order to detect haplotype-resolved single-nucleotide variants and structural variation in the targeted genes/alleles for freezing and drought genes,
3. Identify novel genes and characterise drought and freezing tolerance genes by comparing their expression for pathway related genes in non-edited and mutant plants,
4. Develop CRISPR-Cas9 constructs and generate CRISPR-edited perennial ryegrass mutants for freezing and mild drought tolerance,
5. Validate and characterise the role of the genes and their sequence variations in the freezing and drought mechanisms.



▲ Setting up a perennial ryegrass collection in a phytotron

2. NOBAL wheat-breeding toolbox for sustainable food system of the NOrdic BALtic region.

Project principal investigator Dr Gintaras Brazauskas. 2021–2023.

Bread wheat accounts for nearly 50% of European cereal production. However, European crop yields have stagnated in major production areas due to abiotic and biotic stresses caused by climate change. Global wheat production is predicted to expand towards the Northern regions. Breeding climate-resilient wheat varieties is an important research task for the Baltic and Nordic countries to ensure safe and sustainable food systems. **The NOBAL wheat aims** to establish a spring wheat collection originating from Baltic states and Norway and test it's genetic plasticity and adaptation capacity to the climate change for different countries within three years by phenotyping and genotyping it. Superior genotypes will be directly introduced into breeding programs for the development of disease- and abiotic stress-resistant varieties.

In combination with genotypic data, NOBAL wheat collection will provide highly valuable material for use as a training population, and this will be a starting point to introduce genomic selection into breeding programs across Baltic countries. Setting up low-cost high throughput phenotyping platforms and introducing these into breeding programs across the Baltic countries will increase food security in the Nordic-Baltic region. Identification of vegetation indices and morphological traits for wheat plant responses to biotic and abiotic stresses, will allow to utilize it in precision agriculture with the goal of optimizing returns on inputs while preserving resources. All partners will benefit from know-how and technology transfer and will make use of the climate-fit wheat varieties to secure yields and ensure sustainable food systems and will profit from the advanced field sensing technology which is an important part of digitalization in future agriculture.

▲ Phenotyping of spring wheat with phenomobil at the experimental fields of the LAMMC

▲ Spring wheat experimental fields of the project partner, the Institute of Agricultural Resources and Economics (AREI)

Other projects of EU programmes supporting research

Lithuanian-French programme "Gilibert" for bilateral cooperation. Impact of urban trees on air pollution and human health.

Project coordinator Dr Valda Araminienė, Institute of Forestry. 2021–2022.

Air pollution is one of the most serious environmental problems in Europe. Mortality from the effects of air pollution has been found to be ten times higher than the number of people killed in car accidents. It is important to focus on improving urban air quality. Urban forests make a significant contribution to reducing air pollution but growing trees in densely populated cities is not easy.

In this project, researchers from two countries are collaborating to model situations to eliminate/reduce air pollution in an urban area. The project partners from ARGANS are experts in the field of air pollution and the effects of climate change on forests and human health. Using the Urban FORest Effects (UFORE) model and using GIS capabilities, the project aims to quantify the role of current forest cover in cities (absorbing air pollutants and carbon) and to assess the impact of forests on air quality.

▲ The project team

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COST Action

CA20132 Urban Tree Guard – Safeguarding European urban trees and forests through improved biosecurity (UB3Guard).

Coordinator in the Institute of Forestry, member of the Management Committee, and leader of WG2 "Innovations" Dr Diana Marčiulynienė. 2021–2025.

Green infrastructure, including urban forests, has been proposed by the European Commission as a strategy to support climate adaptation capacity and sustainable development in the urban areas with over 70% of the population of the EU. Alarmingly, the green infrastructure and especially its characteristic elements, trees, are increasingly threatened by alien pests (insects and pathogens) that are introduced via trade and transports. In a new environment, these pests may become invasive, causing devastating environmental and economic losses, and threatening also unique cultural values such as those linked to veteran trees. The current biosecurity system fails to capture alien pests that often also benefit from the altered climate. New tools and better integration of different knowledge pools are urgently needed to support better biosecurity in urban settings.

The main aim of the Action is to co-create (involving researchers and stakeholders) and recommend science-based, socially acceptable, and harmonized prevention strategies and technological solutions for safeguarding urban trees. The desired impact is a reduced risk of tree pest entry and establishment in urban greenspaces and further spread to native woodlands.

The Action contributes to the goals of the European Green Deal and Biodiversity Strategy for 2030 by protecting the health of urban trees. It also adheres to FAO's global level work on UPF (e.g., "Tree Cities of the World" programme), contributing with a specialised perspective (biosecurity).

The topic is relevant for a broad range of disciplines, including forest pathology, forest entomology, ecology, landscape architecture, urban forestry and planning, and arboriculture. Potentially interested actors can also be found from the field's social sciences (e.g. environmental psychology), health care and medical sciences (e.g., "green rehabilitation", "forest bathing"), and nature pedagogics.

8.3.2. International projects ongoing in 2021

In 2021, the Lithuanian Research Centre for Agriculture and Forestry continued to implement **20** projects of various international programmes. This section provides descriptions of the ongoing international projects under the "Horizon 2020", LIFE, and EUREKA programmes.
A full list of the projects is provided in the annexes.

"Horizon 2020" projects

1. Towards climate-smart and sustainable soil management (EJP SOIL).

Project coordinator Dr Žydrė Kadžiulienė, Institute of Agriculture; deputy coordinator Dr Virginijus Feiza. 2020–2024.

Fertile and productive soils are the prerequisite for a stable supply of food, fibre, animal feed, timber, and other biomasses. Soils are part of the solution to realising the SDGs.

The "Horizon 2020" project EJP SOIL unites a unique group of 26 leading European research institutes and universities in 24 countries.

The main objective of EJP SOIL is to create an enabling environment to enhance the contribution of agricultural soils to the key societal challenges, such as climate change adaptation and mitigation, sustainable agricultural production, provision of ecosystem services and prevention of soil degradation and restoration of land. Through sustainable soil management, it is possible to preserve and even enhance the provision of ecosystem services by soil and biodiversity. Soil management can also be climate smart, contributing to mitigation of climate change by carbon storage and to adaptation of agroecosystems to changing climate. The implementation of climate smart sustainable soil management differs from region to region, between agricultural practices and obviously between different soil types. EJP SOIL activities in interaction with stakeholders will pursue the long-term goal of promoting farmers as stewards of land and soil resources and support policy development and deployment, in particular the CAP and Climate policies.

In 2021, six new EJP SOIL projects were won: TRACE-Soils, i-SoMPE, STEROPES, SensRes, CarboSeq, SIREN.

More information about EJP SOIL can be found at www.ejpsoil.org andwww.lammc.lt, a short video created in 2021: https://www.youtube.com/watch?v=2omCQHMPxlw.

Estimation of the granulometric composition, one of the key indicators of soil productivity

2. Stepping-up IPM decision support for crop protection (IPM Decisions)

Project coordinator Dr Roma Semaškienė, Institute of Agriculture. 2019–2024.

We are getting closer to the Integrated Pest Management (IPM) Decisions Platform, which aims to provide a "one stop shop" for decisions support in integrated pest management. It will consist of a web-based framework that will provide farmers, advisors, and researchers with an access to a wide range of decision support systems and weather data from across Europe.

During second round seminar in 2021, the design and functionality of the platform were presented by researchers from the LAMMC. Participants in the workshop completed the second survey. Twenty farmers, 45 advisers/agronomists, 26 researchers, and two developers of Decisions Support System (DSS) from Lithuania participated. The importance of some factors in a farmer's decision to adopt a given DSS was evaluated. The price of DSS access, the farmer's exposure to demonstrations of the use DSS, and training were rated as very important. Farmer's education and access to high-speed internet was also estimated as important, but the farmer's gender was irrelevant.

A demonstration version of the IPM Decisions Platform was produced and was presented during mid-year meeting in November. This platform will provide farmers, advisors, and researchers with the ability to assess the reliability and suitability of different decision support systems so they could select those that are most suited to their needs.

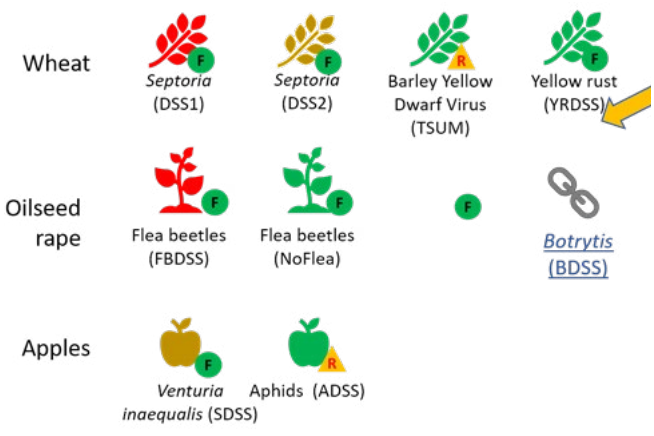

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Figure 8. Colour-based risk assessment of different combinations of harmful organisms

1. Demonstration of climate change mitigation potential of nutrient rich organic soils in Baltic States and Finland (LIFE OrgBalt).

Project coordinator Dr Kęstutis Armolaitis,
Institute of Forestry. 2019–2023.

The aim of the project is implementation of innovative Climate Change Mitigation (CCM) measures in nutrient-rich organic soils in Temperate Cool and Moist (TCM) climate region to contribute to the United Nations Framework Convention of Climate Change (UNFCCC) Paris agreement, EU policies (e.g. Regulation (EU) 2018/841, LULUCF regulation), and national climate policy targets in post-2020 period by reduction of greenhouse gas (GHG) emissions from cropland, grassland, and forest land on nutrient-rich organic soils (Terric Histosols). In 2021, the first measurements of GHG (CO_2, CH_4, N_2O) emissions were carried out on drained (at permanent plots in cropland, perennial grassland and Norway spruce, black alder and birch stands), and on undrained (perennial grassland, shrubland, black alder and birch stands) nutrient rich organic soils. Preliminary results showed that in the winter, spring, and summer period of 2021, total CO_2 emissions from organic rich soils, especially undrained ones, exceeded the annual emission factors (IPCC 2014, 2013). Meanwhile, total CH_4 and N_2O emissions in most cases did not exceed the annual emission factors. However, obtained results may have been affected by exceptional meteorological conditions (prolonged drought and heat) in 2021. Therefore, the first results are preliminary, and this research will be continued in 2022–2023.

▲ Measurements of GHG emissions (CO_2, CH_4 and N_2O) from a low-lying peatland in winter

2. Nutrient recycling circular economy model for large cities – water treatment sludge and ashes to biomass to bio-energy (NutriBiomass4LiFE).

Project coordinator Dr Lina Žičkienė,
Institute of Agriculture. 2018–2022.

The model of the utilisation of integrated circular economy wastes containing nutrients – the final use of sewage sludge and the corresponding amount of biomass ash for biomass production has not yet been developed and implemented in the countries of the European Union. Therefore, this project is also innovative, since dried anaerobically treated sewage sludge will be used for the fertilisation of energy plants, which is more environmentally friendly than sewage sludge treated in other ways.

▲ Didžiausias (120 ha) antramečių tuopų laukas Europoje, Burnėnų k., Molėtų r.

The aim of the project is to develop and implement a demonstration model of a full-cycle circular economy in large cities for the full use of urban waste, which contains many valuable nutrients – municipal sewage sludge and biomass ash – for biomass cultivation and its further conversion into renewable energy.

Results of 2021: 350 ha of new biomass plantations were established; 4700 t dry sewage sludge and 573 t of biomass ashes reused; 236 t of total N, 118 t of total P, and 9 t of K reused; the area of 290 ha has improved soil quality, especially the carbon and nutrient balance.

▲ Annual project inspection, Griciūnai village, Vilnius district

EUREKA Programme Project

Developing of novel symbiotic functional drink with different plant based fractions using *Medusomyces gisevii* culture.

Project coordinator Prof. Dr Pranas Viškelis, Institute of Horticulture. 2020–2023.

The aim of the project research is to develop a functional fermented probiotic drink using a symbiotic culture of *Medusomyces gisevii* and plant-based fractions as the enzymatic base.

The project develops knowledge about matrices of beverages fermented with symbiotic culture, enriched with biologically active substances, their technological properties, complex indicators of quality, safety, and biological value. The results of the project were presented at the 11th Congress of Probiotics (11th Probiotics, Prebiotics & New Foods, Nutraceuticals and Botanicals for Nutrition & Human and Microbiota Health, 2nd Science and Business Symposium. Rome ,21) and in two scientific publications (Raudonė L., Mindaugas Liaudanskas M., Vilkickytė G., Kviklys D., Žvikas V., Viškelis J., Viškelis P. 2021. Phenolic profiles, antioxidant activity and phenotypic characterization of *Lonicera caerulea* L. berries, cultivated in Lithuania, Antioxidants, 10: 115. https: //doi.org/10.3390/antiox10010115; Zvikas V., Urbanaviciute I., Bernotiene R., Morkunaite U., Balion Z., Liaudanskas M., Viskelis P., Jekabsone A., Jakštas V. 2021. Investigation of Phenolic Composition and Anticancer Properties of Ethanolic Extracts of Japanese Quince Leaves. Foods, 10 (1), 18. https://doi.org/10.3390/foods10010018).


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▲ Fermentation by the symbiotic culture


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8.3.3. International projects completed in 2021

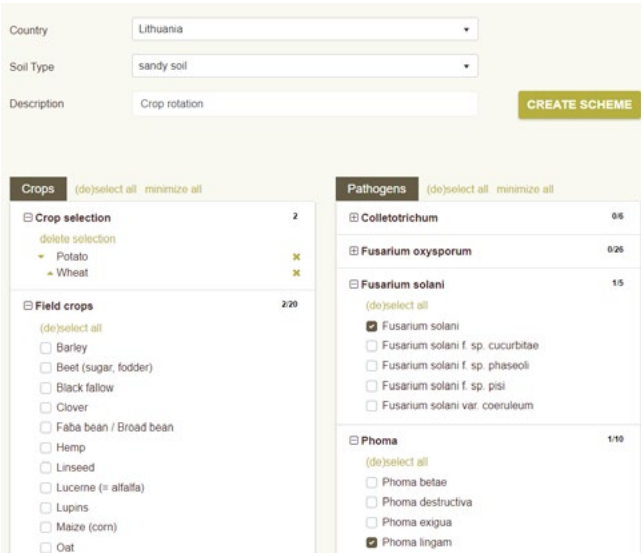
This section presents descriptions of **9** international projects implemented in 2021.

HORIZON 2020 Projects

1. A network of practioners, for sharing knowledge on prevention and reduction of soil borne diseases (Best4Soil).

Project coordinator Dr Antanas Ronis,
Institute of Agriculture. 2019–2021.

The main objective of the project is to maintain, improve, or restore soil health in Europe. During the project period, the website www.best4soil.eu was created, which contains textual and visual information and educational material covering crop rotation, catch crops, organic matter use, (bio) solarisation, and anaerobic soil disinfection. It is mportant to note that two databases covering soil-borne pathogens and nematodes were developed as well. With the help of these tools, it is possible to arrange a proper crop rotation, where the damage of harmful organisms will be at the minimal level and the plants and their products will be as healthy as possible. To increase the availability of information, all material on the website was translated into Lithuanian. It is important to note that this website will be available and constantly updated for the following two years after the end of the project.



▲ The ‚Pathogens' database on the website www.best4soil.eu

The year 2021 was dedicated to sharing information and organising seminars, where participants were introduced to the material and tools available on the webpage of Best4Soil project. Due to the pandemic caused by the COVID-19 virus, all meetings were organized remotely. During this year, a total of eight meetings were organised, the most successful of which was the international seminar "Better crop only in healthy soil", which was held on 4–5 March. During the event, the participants had the unique opportunity to find out the experiences and advice from Lithuanian, Latvian, Polish, and Danish scientists, and about the actions that should be taken to improve soil health. Every day, the seminar attracted about 100 participants. Additionally, Best4Soil project was presented during other events for researchers, college students, agricultural advisers, and farmers.

2. A thematic network to design the penetration path of non-food agricultural crops into European agriculture (PANACEA).

Project coordinator Dr Vita Tilvikienė,
Institute of Agriculture. 2017–2021.

The PANACEA network aims to facilitate the exchange of knowledge and innovative ideas on biomass production between scientists, farmers and industry. In recent years, a number of research projects have been funded to assess non-food crops, develop agronomic practices and introduce them into agricultural supply chains. However, the results of these projects have not been disseminated and put into practice, either because agriculture and the market were not mature for such new concepts, or because the research was limited to single projects disconnected from existing agricultural chains, or the information did not reach the relevant stakeholders.

The aim of the project was to create a thematic network promoting effective exchange between research, industry, and the farming community to plan the integration of non-food crops in European agriculture. The project took stock of both national and international projects, synthesised non-food crop research data, and presented the information in a structured way for students, farmers, producers and consumers. The events organised during the project attracted a large number of participants, indicating a high level of interest in new agricultural plants. It is likely that in the future, in particular with the implementation of the European Green Deal strategy, more and more agricultural biomass will be used for the production of various innovative products.

▲ Non-food crops in the fields of the LAMMC

3. Fostering sustainable legume-based farming systems and agri-feed and food chains in the EU (LEGVALUE)..

Project coordinator Dr Žydrė Kadžiulienė, Institute of Agriculture. 2017–2021.

Demand for protein-rich crops in Europe is high and is not currently covered by domestic production. **The aim of the LegValue project** was to examine the existing shortcomings in the value chain of legumes and to propose solutions. Different obstacles of the project participants from different countries were analysed and stated. The summary conclusions were published in the project results reports, articles, and on the website. In the final years of the project, the focus was on making decisions that would be more conducive to the use of local legumes. Decision-making tools are essential for the wider development of legumes in the crop structure and for their promotion. In order to better understand the necessary measures in the country, we organised the seminar "Identification of good practices and future policy measures", where possible policy measures for the future were discussed.

The project also focused on the practical aspects of grain legume growing and the relationship with farmers. It is very important to reach farmers who are satisfied with legume production, to get in touch with them, and to understand what methods, for what purposes, what indicators they use to evaluate and improve their practices. We visited farmers, interacted with them, and discussed the benefits of beans. In the final years of the project, we identified several successful farmer practices, such as "Field pea: a source for soil fertility and structure in crop rotations", "Peas: direct drill in the crop rotation for proper seeds", "Peas: from crop in rotation to organic seeds". The practices are based on the feedback from the farmers themselves collected during interviews with them. These success stories with technological descriptions were presented to the project partners. We attended the LegValue General Assembly and the final meeting of the project. The latest legume research results from our team are summarised and three scientific articles are submitted to scientific journals.

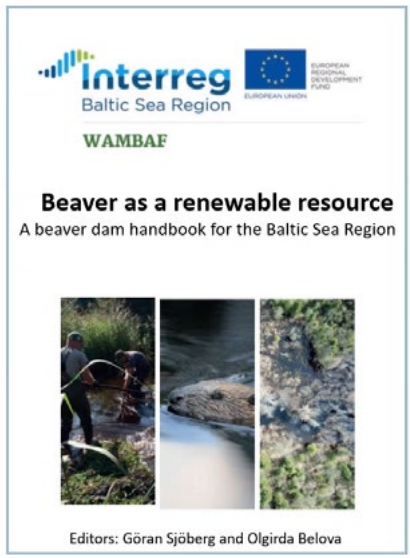
▲ A field of peas

INTERREG Programme Projects

1. Water Management in Baltic Forests Tool Box (WAMBAF Tool Box).

Project coordinator Dr Olgirda Belova, Institute of Forestry. 2019–2021.

The aim was to upscale and adapt the tools developed in the previous WAMBAF project and to implement these tools to a wider target group. The main outputs are upscaled and adapted to a wider target group, including machine learning wet area maps, avoiding negative impact on water quality and unacceptable driving in forests; beaver impact maps at catchment scale which



▲ The project resulted in a book

serve for decision support on beaver ponds at landscape level in the context of water quality and climate change; the international training course "Towards upscaling and adaptation of the beaver decision support tool and beaver handbook" was organised; Blue Targeting tool was adapted to a wider territory in NW Russia; the mobile application for smart phones was prepared for easier use in forestry. The films on forestry operations for water consideration were prepared and published online to make them easier to understand. The manual on forest drainage as practical tool was prepared for the machine operators to perform drainage operations. The book *Beaver as renewable resource: a beaver dam handbook for the Baltic Sea region* was published.

2. Market driven authentic Non-Timber Forest Products from the Baltic region: focus on wild and semi cultivated species with business potential (NovelBaltic).

Project coordinator Dr Jonas Viškelis,
Institute of Horticulture. 2019–2021.

The aim of the project was to enhance the business potential of non-timber forest products (NTFP) by developing authenticity and quality demonstration methods for selected materials.

The project resulted in:

• an overview of the market demand for forest products (other than timber) in the Beijing region and certain regions of Southeast Asia;

• development of a digital platform for methods of authenticity and quality of raw materials;

• developed methods for determining authenticity and quality;

• evaluation of raw materials and production processes.

The final report was written and submitted to the project manager. Research results were presented at the international webinar "Discover the potential of Nordic forests – business and science" and published in the scientific publication: Klavins, L., Maaga, I., Bertins, M., Hykkerud, AL, Karppinen, K., Bobin, Č., Salo HM, Nguyen N., Slminen H., Stankevica K., Klavins, M. 2021. Trace Element Concentration and Stable Isotope Ratio Analysis in Blueberries and Bilberries: A Tool for Quality and Authenticity Control. Foods, 10 (3), 567, p. 1–13.

▲ Bilberry authenticity test

Other projects of EU programmes supporting research

1. Collaborative action for updating the documentation about berry genetic resources in Europe

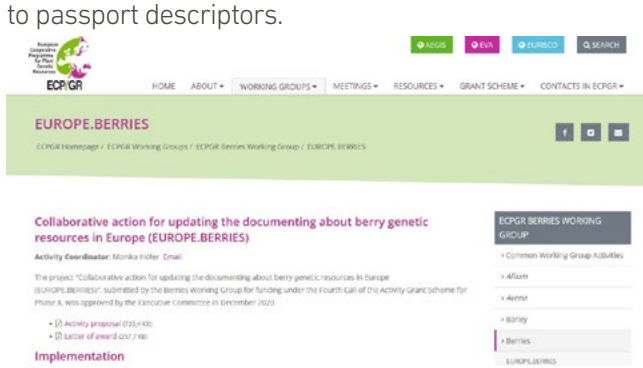
Coordinator Dr Rytis Rugienius,
Institute of Horticulture. 2021.

Tasks of the project:

1. To provide passport and phenotypic information of actively conserved European Plant Genetic Resources for Food and Agriculture (PGRFA) diversity *ex situ* through the European Search Catalogue for Plant Genetic Resources (EURISCO).

2. Efficiently conserve and provide access to unique germplasm in Europe through A European Genebank Integrated System (AEGIS) and the European Collection.

Video conferences with all activity partners were held on 21 April and 28 September. In particular, the work on the verification of the inventories of the genetic resources of berries was discussed. Seventeen institutions from 16 European countries participated in the project. Lithuanian participants Dr Rytis Rugienius and A. Sasnauskas were responsible for checking the participants' national inventory lists of strawberry (Fragaria) collections of genetic resources. Collection lists was checked, corrected, and harmonised according to passport descriptors.



▲ The EUROPE.BERRIES website

2. Inter-institutional collaboration project *Ash-Adapt – evolutionary potential of natural Fraxinus excelsior populations challenged by novel pests and pathogens.*

Project coordinator Dr Rita Verbylaitė,
Institute of Forestry. 2019–2021.

Objective: to identify the SNP markers associated to ash dieback resistance and other fitness-related characters including sex and phenology.

Activities: The identification of SNPs was based on existing clonal trials where the ash dieback disease was assessed in the course of several years. The assessment followed a joint protocol and included assessments of trials

in Denmark, Sweden, Germany, Austria, and Lithuania. Several traits were assessed according to the joint protocol: spring flushing (2 times), ash dieback susceptibility, and autumn senescence. During the implementation of the project, the samples of ash trees in natural, disease-affected populations were collected and analysed. Results will be shared and a publication on SNP identification (Genome-wide Association Study) will be developed and co-authored together with other European collaborators. The manuscripts are under preparation. Lene Rostgaard Nielsen is the overall principal investigator (PI) for the project. Dr Rita Verbylaitė is the PI from the Institute of Forestry, Lithuanian Research Centre for Agriculture and Forestry, and Prof. Dr habil. Alfas Pliūra is the collaborating researcher.

▲ A grafted *Hymenoscyphus fraxineus* pathogen-resistant seedling of the European ash

3. Nordic Forest Research Co-operation Committee (SNS) project "Preventing the spread of new pathogens in Nordic forests to secure sustainable forestry in growing bioeconomy".

Coordinator Dr Diana Marčiulynienė,
Institute of Forestry. 2019–2021.

The aims of the project was to support development of early detection solutions to stop introduction of pathogens (task 1) to improve science-based knowledge about the mechanisms of forest pathogen invasions (task 2), to contribute to the formation of guidelines for sustainable forest management strategies, to mitigate the effects of introduced pathogens (task 3), and to improve the awareness of different actors in society about the risks of pathogen invasions and strengthen the science-society interaction in questions related to forest health (task 4).

Based on the results of the study, a review paper is being developed covering early detection methods to improve biosecurity against alien invasive forest pathogens and forest management strategies to fight the introduced invasive forest pathogens.

4. European Cooperative programme for Plant Genetic Resources project "Facilitating use on the European perennial ryegrass collection: improving access to genetic resources and C&E data".

Project coordinators Dr Eglė Norkevičienė (2018),
Dr Gražina Statkevičiūtė (2019–2022),
Dr Vilma Kemešytė, Institute of Agriculture. 2018–2022.

The project furthered the achievement of the ECPGR Objectives 1 and 2 of phase IX for perennial ryegrass by taking advantage of the data and results of the FACCE-JPI ERA-NET+ project GrassLandscape.

During 2021, the partners continued implementing Task 3 activities: selecting genotypes to set up different nested levels of core-collections for accessions from the natural diversity of perennial ryegrass and consult members of Forage working group for agreement on inclusion of core-collection flags into EURISCO.

▲ Phenotypical diversity of the perennial yegrass

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8.3.4. National projects completed in 2021

In 2021, **24** national projects were implemented:

- **12** projects of the Research Council of Lithuania,
- **4** projects of the Ministry of Agriculture,
- **5** projects of the Ministry of Environment and its subordinate state institutions,
- **3** projects of the association "RTO Lithuania".

Descriptions of all national projects implemented in 2021 are presented below.

Research funded by the Research Council of Lithuania

Projects of research teams.
EU-funded projects implemented by world-class researcher groups and aimed at developing results in line with R&D topics relevant to the economic sectors, which could then be commercialised

1. Development of wood modifying eco-friendly technology for higher value products.

Project leader Dr Marius Aleinikovas. 2017–2021.

The aim of the project was to create an environmentally friendly technology for the modification of wood properties, based on the reaction of bioactive compounds of wood to the modification reagent ensuring the rational use of ligno-cellulosic material, and giving a higher added value to the products.

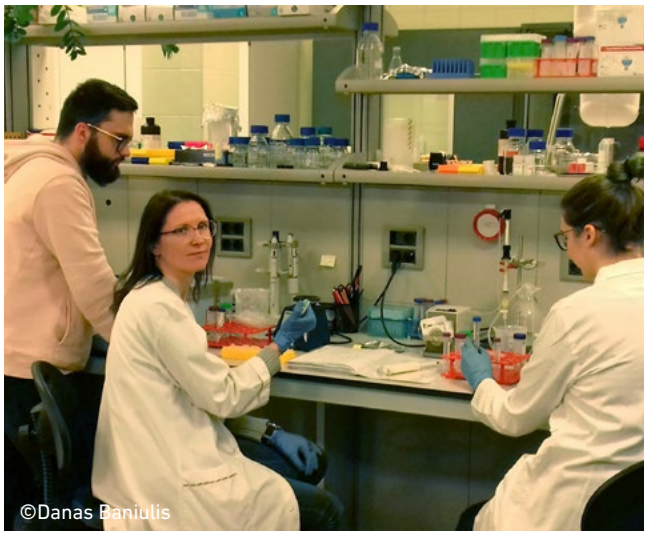
The development of a modifier on the basis of iron oxide or iron salt solution and technological parameters for impregnation applied for different tree species (*Picea abies, Pinus sylvestris, Pseudotsuga menziesii, Juglans Regia, Acer platanoides*) was continued in 2021. The mass loss after thermal processing was obtained in all treatments, including the control treatment, for all species, except the wood of *Pinus sylvestris* and *Picea Abies* in the treatment with additive FeO_3 together with tannins. Among all species, the density of the wood of *Pinus sylvestris* and *Picea Abies* after thermal processing also responded differently than other species, i.e., wood density of these conifers increased after thermal processing. However, wood density of other species – *Pseudotsuga menziesii*, *Juglans Regia* and *Acer platanoides* – evidently increased in the control and $FeCl_3$ with tannins treatments or slightly decreased in Fe_2O_3 with tannins treatment. Generally, different treatments of pure Fe_2O_3 and $FeCl_3$ or Fe_2O_3 and $FeCl_3$ applied together with commercial tannins decreased the content of total phenolic compounds compared with the control treatment in the wood of *Pinus sylvestris*, *Picea Abies* and *Acer platanoides*. More contradictory values were obtained for the wood of *Pseudotsuga menziesii* and *Juglans Regia*.

▲ Testing the durability of wood

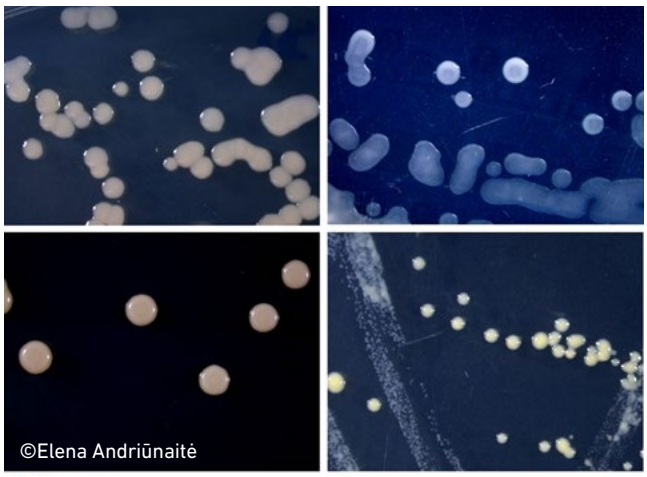
2. Closed plant cultivation system for production of raw materials for peptide nanoengineering applications.

Project leader Dr Danas Baniulis. 2017–2021.

The aim of the project was to develop a technology based on closed type plant tissue cultivation system dedicated for the production of raw materials for preparation of peptides mimicking the human extracellular matrix proteins (PMEM). In 2021, the study was focused on the new constructs of peptides mimicking functional domains of fibronectin and collagen mimicking peptide. A method for the recombinant protein purification from transgenic tobacco cell line was developed. Purified proteins were characterised using mass spectrometry. In collaboration with the FTMC partner, the recombinant EMIP proteins were used for preparation of surfaces on the bioinert substrate and efficiency of adhesion of human fibroblast cells to the surfaces was assessed. The activity dedicated to optimisation of plant cultivation *in vitro* technology was implemented using endophytic bacteria isolates obtained from tobacco and apple plants. The study revealed that closely related isolates of the *Bacillus cereus* group had different effect on tobacco shoot biomass accumulation and oxidative stress parameters. The genome structure of isolates with contrasting effect on shoot growth had been studied and potential metabolic pathways associated with the plant growth-regulating properties were assessed.



▲ Project scientists Edgaras Tamelis, Jurgita Vinskienė and Elena Andriūnaitė are purifying recombinant proteins



▲ Colonies of isolates of endophotonic bacteria of the *Bacillus cereus* group isolated from tobacco leaves

3. UV-A lighting strategies for controlled environment horticulture: upgrade to sustainable, high-value production.

Project leader Dr. Akvilė Viršilė. 2017–2021.

The project aimed to create a research-result based UV-A lighting application strategy for the improvement of phytochemical value and taste properties in different green vegetables and herbs for high value production in closed environment horticulture systems. The physiological response of different leafy vegetables, herbs, and medicinal plants to different UV-A wavelengths, intensity, and duration were explored; the efficiency of UV-A lighting in combination with different background lighting parameters were evaluated. Lighting methodologies for high value plant cultivation were designed: for the improvement of morphophysiological, organoleptic properties, and biofortification with target metabolites.

▲ Various herbs and medicinal plants under UV-A-supplemented LED lighting

4. Quality diagnostics of biogas production by-product (digestate) for innovative use as a biofertiliser.

Project leader Dr Alvyra Šlepetienė. 2017–2021.

The aim of the project was to evaluate and compare the quality of various agroraw materials available in the country on the basis of scientific knowledge; to reveal their potential for use, considering their suitability for industrial

processing into biogas; to promote the use of residual biomass from biogas plants as bio-fertiliser in agriculture, and to improve its quality diagnostics by developing an innovative and accurate NIR spectrometry method.

Large amounts of organic carbon have been found to accumulate in solid digestate, which demonstrates the benefit of this bio-product in replenishing soil OC. This result is very important as more than one-third of Lithuanian soils have insufficient contents of organic carbon and organic matter. Fertilisation with digestate increases the yield of grassland biomass threefold compared to unfertilised treatment, and grass biomass can be used as a raw material for biogas production. The mathematical relationships between the NIRS spectra and the chemical composition parameters of the digestates had already been obtained in preparation for the patent application. This is expected to provide a more accurate prediction of the impact of bio-products on crop yields, soil and environment.

In 2021, planned publications of the project results were published. A database of the chemical composition of digestates was prepared.

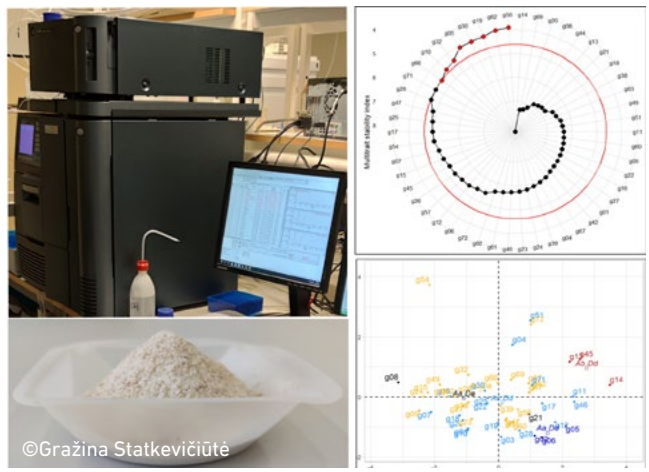
▲ Estimation of the chemical composition of various digestates

5. Development of winter wheat varieties for amylose-free starch and vital gluten processing.

Project leader Dr Gintaras Brazauskas. 2017–2021.

The aim of the project was to develop new winter wheat varieties adapted to North European climatic conditions with specific starch and protein composition by applying innovative and traditional selection methods. In order to determine winter wheat tolerance to freezing temperatures, wheat genotypes were studied under natural and controlled conditions by means of high-resolution imaging and freezing chambers. The results revealed that freezing tolerant lines exhibit slower leaf growth under hardening and fully halt vegetation under lower temperatures, while less tolerant genotypes maintained more intensive growth during hardening. The present study also determined the effect of environment, nitrogen fertilisation and genotype on yield and grain quality traits of winter wheat cultivars and advanced breeding lines. Environmental conditions and nitrogen application were the main factors affecting yield and grain protein content, whereas the variation in gluten protein size fractions was largely determined by the genotype. Three winter wheat varieties were developed in the frame of this project, producing waxy starch ('Eldija' and 'Sarta') or improved protein content ('Vaiva').

▲ Automated high-definition imaging technology to assess the leaf growth rate and dynamics during leaf hardening



▲ Chromatographic analysis of the gluten composition of winter wheat

Smart-Legume

6. Enhancement of the multifunctional properties of legumes in feed and food value chain (Smart-Legume).

Project leader Dr Žydrė Kadžiulienė. 2017–2021.

Food legumes and other legumes are very important, and legume production is viewed as a promising option to mitigate climate change providing nitrogen to the soil and limiting external use of inputs.

The year 2021, the last years of a project, aimed to develop innovative legume-growing systems based on their multifunctional value. Numerous new results on the cultivation, productivity, and quality of new varieties of pea, lentils, and chickpeas were accumulated during this year. First of all, the project participants have completed the development of two new pea varieties, 'Egle DS' and 'Lina DS'. The yield of these cultivars was found to be higher, and more crude protein was accumulated than in the cultivars cultivated previously. Local strains of *Rhizobium leguminosarum bv viciae* were shown to have a positive effect on pea productivity and can be suggested as promising pea inoculants. However, their competitiveness and efficacy under different field conditions need to be assessed. The new pea varieties incorporated in the mixture with oats significantly increased the total yield of the intercrop compared to the intercrop with the standard pea variety. Our results indicate that diversifying crop rotations, including pea, significantly changed crop rotation productivity compared with the cereals rotations. The most important technological elements of new pea cultivation were studied, and the cultivation technologies of specific varieties will be presented to growers.

During the implementation of the project, chickpea and lentil growing technologies in conventional and organic farming systems were studied. The results show that lentils and chickpeas have the potential to grow in our climate; however, research needs to be continued and expanded.

▲ The new pea variety ‚Egle DS'

Projects of the national research programme "Sustainability of agro-, forest, and water ecosystems"

1. Management of greenhouse gas emissions by changing nitrogen flows in the agro-system.

Project leader Dr Vita Tilvikienė. 2020–2021.

Long-term changes in the agricultural ecosystem are influenced by intensive farming, and the use of mineral fertilisers is directly related to greenhouse gas (GHG) emissions. In this context, reduction of GHG emissions is one of the key challenges in climate change mitigation. In the agrarian sector, this issue could be at least partially addressed by changing the sources of nitrogen, in particular by replacing inorganic fertilisers with organic ones without reducing farm competitiveness.

One of the substances that could at least slightly change the use of mineral fertilisers could be digestate, a bio substrate processed in the biogas production process. According to preliminary research results, digestate made from pig manure has the same effect as mineral fertilisers on spring wheat grain yield and quality, and soil microbial biomass, while the increase in greenhouse gas emissions from soil is slightly higher compared to mineral fertilisers only after fertilisation, while later the opposite is observed.

Research has shown that the nitrogen concentration in digestate is reduced by only 13% compared to the raw material used for biogas production, so almost all of the nitrogen in pig manure remains in the recycled substrate. Therefore we can assume that digestate is an effective raw material for fertilisation.

▲ Studies on the effectiveness of organic fertilisers under controlled conditions

2. Sustainable forage crops productivity under climate extremes: resilience, nutritional quality, and implications for future management.

Project leaders Prof. Dr habil. Romualdas Juknys (VMU), Dr Vaclovas Stukonis (LAMMC). 2020–2021.

The aim of the research was to assess the effects of extreme climatic conditions on the resilience and nutritional quality in fodder crops and to develop guidelines for sustainable cultivation and management of fodder grasses. The results of the research suggested that different species and varieties of forage grasses responded differently to extreme climatic conditions. Alfalfa was the species most tolerant to drought and heat. The quality of the yield and feed of this species may even increase due to drought and heat effect. Meanwhile, timothy was less tolerant to drought and heat stress, while red clover and perennial ryegrass were medium tolerant to those stress. Recovery was different among species after the impact of heat and drought stress. Alfalfa and red clover are likely to recover faster than timothy. Cultivation of alfalfa and mixture with perennial ryegrass or × *Festulolium* should be increased due to global warming, while cultivation of timothy should be reduced. Research showed that optimal rates of mineral fertilisers increased the resistance of grasses to adverse climatic conditions.

▲ Experimental plots of the impact of extreme weather phenomena on the resilience and nutritional value of forage crops

3. Dynamic changes and restoration of soil properties, fungal and insect communities following clearcutting and biomass utilisation in pine ecosystems.

Project leader Assoc. Prof. Dr Artūras Gedminas. 2020–2021.

The objective of the project was to conduct multidisciplinary research obtaining fundamental and applied knowledge on soil properties, restoration of fungal and insect communities in pine ecosystems disturbed by forest clearcuttings and intensive biomass utilisation. Results of chemical forest soil analysis showed that the chemical properties of forest litter differed between both the regions and the different development stages of Scots pine forest ecosystem in each region. The most significant differences between the stages of the ecosystem development were found in Varėna, and the smallest changes were found in Alytus-Punia region. After clear cutting (in the fresh clear-cut of former Scots pine forest and in 1–2-year-old reforested sites), a significantly higher concentration of mineral nitrogen was found in the 0–20 cm depth mineral topsoil: in all regions it differed about six times, and compared to the mature forest, the highest difference was recorded in the one-year-old reforested site in Švenčionėliai-Labanoras region. In 3–4-year-old reforested sites, the concentrations of studied chemical elements in the mineral topsoil up to 20 cm depth became similar to the concentrations of these elements in a mature forest. Analysis of insect abundance in stumps with the different degradation level showed that the number of xylophages exit holes increased with the age of stumps. The number of xylophages from the stumps in 3–4-year-old pine plantations was higher than from stumps examined in mature pine forests in all study regions. In contrast to the stumps, the number of xylophages from the branches with different decomposition level was significantly higher in mature pine forests than in the felling sites.

▲ Spring dumbledor, (*Trypocopris vernalis*), the forest orderly

▲ An aspen damaged by the black fungus *Inonotus obliquus*

Development of scientific competence of scientists, other researchers, and students through practical scientific activities funded by the European Union funds

Sub-activity "Development of students' abilities in scientific (art) research during semesters"

1. The impact of *Fraxinus excelsior* and *Populus tremula in vitro* cultures and symbiotic bacteria interaction on the development of antipathogenic resistance in these trees.

Doctoral student Greta Striganavičiūtė, supervisor Dr Vaida Sirgedaitė-Šėžienė. 3 November 2020–30 April 2021.

The aim of the study was to evaluate the influence of plant symbiotic bacteria from the genera *Paenibacillus* and *Pseudomonas* on the development of pathogen resistance mechanisms in forest trees.

It was determined that:

1. *Paenibacillus* sp. and *Pseudomonas* sp. inhibited the development of shoots and roots of the aspen hybrid Wa13 (*P. tremula* × *P. tremuloides*); 91/78 (*P. alba* × *P. tremula*), both bacteria inhibited shoot growth, but *Pseudomonas* sp. promoted root growth, and for the R-38 genotype, *Pseudomonas* sp. promoted rooting. *Pseudomonas* sp. negatively affected the development of shoots and roots in 17-040, 33-077 and 61 ash families, reduced shoot growth in 87 and 174 families, and reduced root growth in 01-062 families. *Paenibacillus* sp. inhibited shoot growth in 87 families but promoted root growth in 61 families.

2. The highest concentrations of TPC and TFC were found in the R-38 genotype control. Its interaction with *Pseudomonas* sp. led to a decrease in TPC and TFC. *Pseudomonas* sp. higher TPC and TFC were found in the shoots of aspen genotypes adversely affected. Meanwhile, the highest TPC and TFC were found in the 01-062 and 33-077 ash families and in 61 and 87 ash families with lower levels of secondary metabolites in the control.

3. The previous response of *Pseudomonas* sp. impact. Aspen for genotype R-38 *Pseudomonas* sp. and a combination of *P. tremulae* effects resulted in a 2.5-fold increase in mean shoot length compared to controls.

▲ A European ash shoot after inoculation with *Hymenoscyphus fraxineus* pathogen *in vitro*

▲ Scots pine seedlings exposed to low temperature plasma

2. Characterisation of brown rot pathogens genetic diversity using microsatellite markers.

Doctoral student Raminta Žukauskaitė,
supervisor Prof. Dr habil. Vidmantas Stanys.
3 November 2020–30 April 2021.

The aim of the project was to characterise *Monilinia* spp. genetic diversity in *Rosaceae* family plants, using microsatellite markers.

In order to generate microsatellite primers (SSR) for *M. fructigena* and *M.laxa* pathogens, bioinformatic methods for microsatellite searches in *Monilinia* spp. genomes were performed and 39,216 microsatellite motives were identified. Based on the generated SSR data, 26,366 microsatellite markers for three *Monilinia* species were created. Species-specific markers were identified by in silico PCR: 98.6% for M. fructicola, 96.3% for *M. fructigena*, and 96.0% for *M. laxa* pathogens. To analyse the specificity of microsatellites in laboratory conditions, 16 proteins associated with pathogenicity in the *M. fructicola* genome were selected and 2 745 microsatellite motives were identified. Four-hundred-and-seventy (470) species-specific primers were created: 113 – *M. fructigena*, 188 – *M. fructicola*, 169 – M. laxa. To verify SSR marker specificity

in laboratory conditions, PCR was performed with eight SSR markers and the results were evaluated on the agarose gel; the results of four PCR were evaluated by capillary electrophoresis. ML2 and MFg2 primers were shown to be reliable in separating *Monilinia* species, and ML86 were shown to be suitable for characterising intraspecific and interspecific genetic diversity.

During this project, for the first time, microsatellite sequences were developed for *M. fructigena* pathogens and the genetic diversity of *Monilinia* common species was evaluated by SSR marker polymorphism.

▲ Cherry fruit affected by stone fruit moniliasis

3. In-season prediction of cereal nitrogen status and yield with an unmanned aerial vehicle (UAV).

Doctoral student Ardas Kavaliauskas,
supervisor Dr Renaldas Žydelis.
3 November 2020–30 April 2021.

The aim of the project was to assess the possibilities of using data remotely collected by UAV in predicting barley grain yield, its quality, and uptake of macroelements (nitrogen, phosphorus, potassium).

To achieve the aim, the following six main activities were carried out: analysis of scientific literature, merging the images taken by the unmanned aerial vehicle into one high-resolution orthophoto, calculations of plant vegetative indices, development of regression-correlation models using both experimental ground and air distance data, analysis of the obtained data, and, finally, preparation of report based on the obtained results during the project and oral presentation at the Student Scientific Conference organised in 2021 by the Research Council of Lithuania.

Main findings: the most accurate predictions in the analysis of barley yield and other indicators were obtained using RGB indices at their initial stages of growth and development, i.e., tillering (BBCH21) and stem elongation (BBCH32); in subsequent stages, the accuracy of the forecasts gradually decreased. It was determined that the most suitable indices for barley grain yield predictions were ExGR, COM, VEG, NGBDI; for protein content, ExGR, COM, VEG, ExG, for nitrogen uptake in grain, ExGR, MGRVI, VEG, ExB; for phosphorus uptake in grain, ExGR, COM, VEG, NGBDI; for potassium uptake, ExGR, COM, VEG, ExB. A database of one-year barley indicators, which consisted of actual measurements of grain yield, its quality and nutrient uptake obtained during the performed fertilisation experiment, was developed. Continuing the experiment, the barley data will be further collected and used for calibration, verification, and improvement of prediction models.

▲ Project participant Ardas Kavaliauskas with a drone

Applied research funded by the Ministry of Agriculture

Research and applied activities projects in agriculture, food and fisheries

1. Glyphosate and AMPA residues and its degradation time in soil and grain.

Project leader Dr Gražina Kadžienė. 2019–2021.

The aim of the project was to investigate the persistence of residues of glyphosate and AMPA in various types of soils and crop production under Lithuanian agro-climatic conditions and to assess the risk of glyphosate products entering adjacent fields.

The research revealed that under the agroclimatic conditions of Central Lithuania, glyphosate could be detected in the soil for up to 2–3 years and most of it decomposed during the first year. Meanwhile, AMPA could persist for several years, and minimal levels of <0.02 mg/kg could be found in the soil even in fields that had never been sprayed. For this reason, glyphosate levels above 0.02 mg/kg should only be considered significant. Studies have shown that glyphosate and AMPA in the soil do not enter the cereals and that adventitious amounts are within the laboratory reporting limits. Residues of glyphosate and AMPA in grains/seeds of wheat and oilseed rape sprayed before harvest were

generally below the maximum levels; they are not allowed in buckwheat grains. The content of glyphosate and AMPA in harvested grains was almost constant, even after storage for two years. Assessing the risk of background contamination when spraying with different parameters of sprayers under different conditions, it was found that even in the presence of moderate winds, the possible drift might appear up to 25–30 metres, while spraying in extreme conditions (high wind) could reach up to 100 metres drift. This indicates that the risk of pesticide contamination of adjacent fields is very high if spraying recommendations are not followed.

▲ Sampling of undisturbed soil for analyses

2. Complex investigation and economic-environment evaluation of no tillage (No-till) technology.

Project leader Prof. Dr Vaclovas Bogužas (VMU), coordinator Dr Virginijus Feiza (LAMMC). 2019–2021.

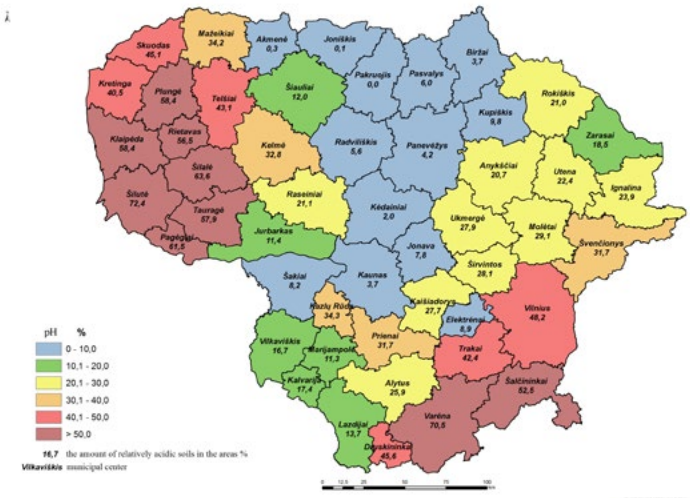
The goal of the project was a complex investigation of No-till technology, its evaluation from the economic and environmental viewpoint as well as in relation with climate change interaction. The LAMMC participated in this research by providing data from long-term tillage-fertilisation field experiments. After project completion, the recommendations for practice will be issued.

▲ Clearly formed soil structure is an indication of high productivity

3. Long-term monitoring of soil agrochemical properties.

Project leader Prof. Dr habil. Gediminas Staugaitis. 2016–2021.

Studies into agrochemical properties of soil, including pH, plant nutrients, and their variations are very important at the national level. It is an integral part of the land information system (LIS) and land productivity assessment. The information systematised on the basis of these studies is used by agricultural entities, advisory services, educational and scientific institutions, planning organisations, municipalities, etc. The research material is important in assessing soil



▲ **Figure 9.** Map of conditionally acid soils

degradation, CO_2 emissions, calculating the fertiliser balance, selecting optimal fertiliser ratios, and solving other ecological issues on national and regional levels.

The staff of the Agrochemical Research Laboratory of the Institute of Agriculture, LAMMC, collected soil samples from 40,000 ha in Klaipėda, Jurbarkas, Radviliškis, and Vilnius districts and Elektrėnai municipality for long-term field research of agrochemical properties (pH, mobile P_2O_5 and K_2O). Soil pH, mobile phosphorus, and potassium were determined in the samples taken. The research results were also evaluated and compared with previous surveys of the respective territories (districts). Accordingly, the set of digital cartographic material with data on soil pH, mobile phosphorus, and potassium (Dirv_AgrochDR10LT) is being updated on the spatial information portal www.geoportal.lt. Maps of soil acidity, fields with similar soil properties (mobile P_2O_5 and K_2O) were also compiled, their change trends were analysed, a final report and an information article "Soil agrochemical research in the implementation of the EU Green Course" were prepared.

Support for the Lithuanian beekeeping sector

Comparison of protein composition of mixed aphid and honeydew-nectar honey with monofloral clover nectar honey.

Supervisor Dr Violeta Čeksterytė. 2021.

The aim of the study was to identify the proteins in mixed honeydew-nectar honey, depending on the contribution of pollen collected from nectar-producing plants, aphid honeydew, and abundance of extrafloral nectar secretions from various parts of plants in honey. Experimental data were compared with pure clover nectar honey. Monofloral clover and rapeseed honey with aphid honeydew containing elements and without honeydew subjective elements of the aphid, but with micro-point images were collected for the research. Pollen was visualised under a light microscope Nikon Eclipse E600 at a 400x and compared to the digital images of the same pollen view in the catalogue. Honeydew elements composed from 7.0% to 11.0% in the analysed honey samples, their images were visualized in microscopic photographs. Protein was extracted from the sediments of prepared honey preparations obtained by centrifugation of pollen. For the first time, high levels of red clover (*Trifolium pratense*) proteins were identified in the honey samples tested; total 42 proteins were assigned to *Trifolium p.* plants.

Honeybee specific lactic acid bacteria *Api Lactobacillus* and *Lactobacillus apinorum* were identified in honey samples. According to the study data, on average, the protein content of *Lactobacillus apinorum* in *lactic acid bacteria* in all samples was 1.3 times higher compared to *Apilactobacillus kunkeei*.

The appearance of the latter microbiota in honey can be related to the extrafloral nectar collected by bees. This nectar is extracted by plants from extrafloral nectaries. Lactic acid bacteria can multiply in extrafloral nectar. The protein content was significantly higher in honey samples, where red clover (*Trifolium pratense*) pollen accounted for 47.5%.

▲ Honeydew elements in honey

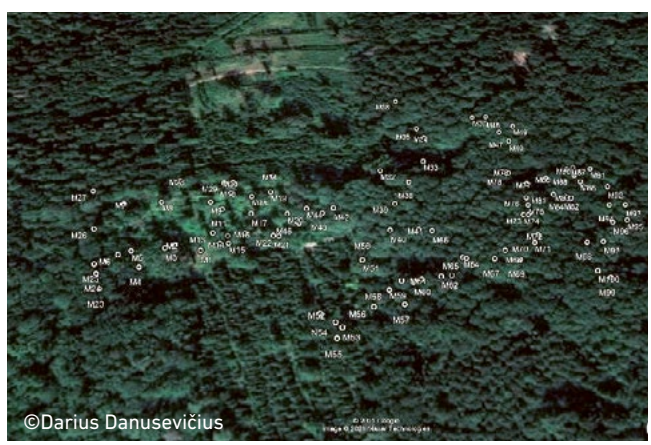
Applied research funded by the Ministry of Agriculture and its subordinate institutions

1. Preparation of genetic monitoring methodology for Scots pine, Norway spruce, pedunculate oak, and silver birch

Project leader Dr Virgilijus Baliuckas. 2019–2021.

The aim of this project was to prepare a methodology for genetic monitoring of Scots pine, Norway spruce, pedunculate oak, and silver birch in Lithuania and to assess genetic diversity in two genetic reserves or genetic stands of each species.

During the project, a genetic monitoring methodology was prepared for four main tree species in Lithuania, based on reports from European projects and EUFORGEN recommendations. DNA marker sets were selected and tested for each species and laboratory analysis methodologies were developed. Using the developed methodology, the diversity of selected genetic reserves or genetic stands of Scots pine, Norway spruce, pedunculate oak, and silver birch was assessed using molecular



▲ Location of the parental generation of pedunculate oak trees in a study plot in Dzirmiškės Forest District, Alytus Forest Enterprise

markers. All eight stands were evaluated using DNA markers, and the results were described using three genetic monitoring indicators and 25 verifiers. The results obtained during the project are the starting point for monitoring the dynamics of genetic diversity over time, i.e., the transfer of genetic information to subsequent generations of trees. Also, during the project, potential stands for further development of genetic monitoring were selected and a network for genetic monitoring of Scots pine, Norway spruce, pedunculate oak, and silver birch in Lithuania was formed.

2. The first stage of Scots pine intensive breeding (breeding cycle III), based on crossings and progeny testing – selection of genotypes in the field trials, grafting, cultivation of clones, preparation of project for crossings and crossing methodology.

Project leader Dr Virgilijus Baliuckas. 2020–2021.

The aim of the project was to develop a methodology for pine crossbreeding, to select the best genotypes according to the growth of offspring in field trials included in the Genetic Forest Tree Resources Information System, to multiply them by grafting, and to prepare a project for crossbreeding of grafted clones.

In the course of the project, the experience of European countries, where the breeding of Scots pine occupies an important place among other forest tree species, was analysed. Strategic provisions were proposed for the type, duration and intensity of the pine breeding programme. The methodology specifies how and how many breeding populations must be formed in Lithuania, what the course of breeding work must be, and how testing must be performed. A cross-orchard project and a project of cross-breeding work were prepared.

▲ Measurement of wood hardness with Pilodyn 6J in test plantations of Scots pine hybrids

3. Development of a unified methodology for drawing up fertilisation plans.

Project leaders Prof. Dr habil. Gediminas Staugaitis, Dr Aistė Masevičienė. 2020–2021.

The aim of the project was to develop a unified methodology for the development of plant fertilisation plans in order to optimise plant nutrition and prevent soil fertilisation and leaching of nutrients into water bodies. The methodology, which is based on scientific agrochemical research conducted in Lithuania, was adapted to Lithuanian climatic and other natural and farming conditions.

During the project, the experience of three EU countries (Germany, Austria, and Poland), whose climatic and farming conditions are similar to Lithuania, in the development of fertilisation planning methodologies was analysed and suggestions and recommendations on the use of such experience in Lithuania were provided. Also, fertilisation methodologies used in Lithuania were analysed in detail, performing the analysis of their strengths and weaknesses, and recommendations on the possibility to use the accumulated experience in preparing a unified methodology for drawing up fertilisation plans were provided.

The developed unified fertilisation planning methodology includes the calculation of the planned yield, where the planned yield and peculiarities of plant cultivation, the need for plant nutrients (nitrogen, phosphorus, potassium) to grow, pre-sowing, organic fertilisation, soil and its properties on plant yield are assessed. The fertilisation plan includes 57 species of plants or their mixtures, of which: 32 are field plants, 17 garden plants, and eight garden plants.

The methodology provides formulas, algorithms, and coefficients for calculating fertilisation rates. The methodology is presented as a recommendation for the preparation of a fertilisation plan. In developing the fertilisation algorithms, the methodology also paid great attention to environmental

▲ A fragment of the fertilisation program

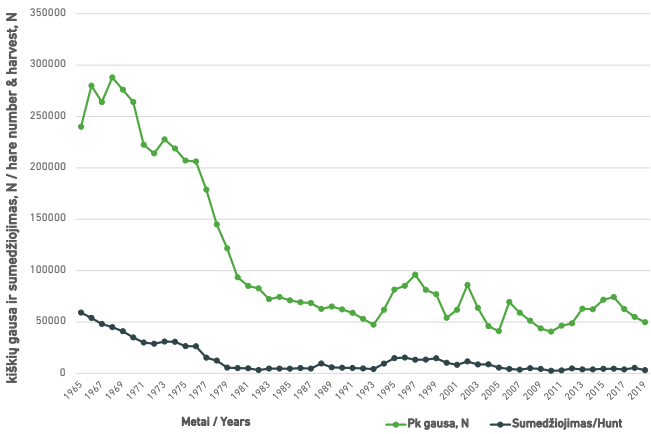
requirements, in accordance with the laws of Lithuania. Based on this methodology, a unified fertilisation programme will be created, which is planned to be applied in Lithuanian farms in the near future.

4. Preparation facility of the grey hare (*Lepus europaeus*) recovery programme.

Project leader Dr Olgirda Belova. 2020–2021.

The aim of the project was to determine the reasons for the decline of the Brown hare (*Lepus europaeus*) and to prepare guidelines for restoration of their resources and species recovery plan. The reasons for the decline of the hare, long-term dynamics of the number and harvest of the hare were analysed and ascertained; the main and secondary threats and their mitigation patterns were distinguished. We determined the species conservation status, goals, and means of the recovery plan. The guidelines for the required actions for implementing recovery plan were prepared. We distinguished the criteria of the recovery actions, the specific localities, time, duration, and periodicity of certain actions. The necessary capacities of the agents and required expenditures were determined considering EC Impact Assessment guidelines and analysing expenditure efficiency (EEA).

▲ Favoured habitat of grey hares



▲ **Figure 10.** The long-term change in the abundance and hunting harvest of grey hares

5. Level II intensive forest condition monitoring and level I forest soil survey in the European network of forest condition monitoring.

Project leader Dr Vidas Stakėnas.
Customer: State Forest Service. 2020–2021.

The objective of the project was to continuously collect, systematise and analyse data on the status of the most common forest ecosystems and their individual components (forest, vegetation, air, soil, etc.), as well as to provide the EU institutions, the public, politicians, and scientists with regular objective information on the state of forest ecosystems and their change.

In 2020, intensive monitoring of forest ecosystems (level II) was carried out in accordance with the planned and multi-year-old scheme harmonised with the requirements and methodology of the ICP-Forests programme. In nine intensive monitoring plots (IMB), the condition and damages to trees were visually assessed according to morphological indicators, air pollution with sulfur and nitrogen compounds, chemical composition of soil solution, amounts of pollutants with atmospheric precipitation (deposition), evaluation of the frequency and intensity of foliage damage caused by ground-level ozone, tree growth, and changes in the diversity and abundance ground vegetation were assessed. In addition, surveys of the forest litter composition and the chemical composition of mineral soils were carried out at the Forest Monitoring Level I European Monitoring Network plots.

In 2021, visually visible ground-level ozone-related damage was assessed in all nine Level II IMBs. Despite the fact that in 2021 the air temperature during the vegetation season was relatively high, no foliage damage similar to that caused by O3 was recorded.

A total of eight soil groups were identified in 81 Level I monitoring areas: *Arenosols* (31 plots), *Luvisols* (26), *Histosols* (7), *Gleysols* (6), *Planosols* (5), *Podzols* (3), *Abeluvisols* (2), *Cambisols* (1).

The total (OL + OFH) forest litter mass in the study plots ranged from 0.11 kg / m^2 to 18.06 kg / m^2 (average 3.39 kg / m^2).

The organic carbon concentration of the OL horizon in sample plots ranged from 161.8 gC / kg to 412.2 gC / kg (average 291.5 gC / kg). The carbon concentration of the OFH horizon ranged from 137.3 gC / kg to 402.8 gC / kg (average 260.9 gC / kg). The average carbon concentration of mineral soils varied from 36.71 gC / kg (0–10 cm depth to 4.42 gC / kg (40–80 cm depth).

▲ A logging site where ground-level ozone foliage damage assessment is carried out

"RTO Lithuania" projects

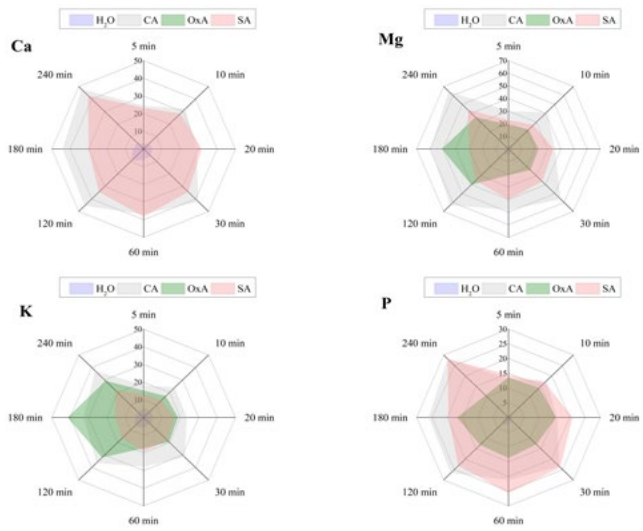
These inter-institutional projects are self-funded by all three member-institutes of the association RTO Lithuania: the Lithuanian Research Centre for Agriculture and Forestry, the Center for Physical Sciences and Technology, and the Lithuanian Energy Institute.

1. Plant nutrients recovery using secondary raw materials (NUTREC).

Project coordinators: Dr Karolina Barčauskaitė (LAMMC), Dr Marius Urbonavičius (LEI) Dr Ilja Ignatjev (FTMC).
2021 m. 8 February–8 December, 2021.

The project aimed to identify technological solutions for the reduction of multifaceted environmental pollution and the extraction of plant nutrients using secondary raw materials.

Biofuel ash and wastewater are rich in nutrients needed by plants. Sustainable recovery of plant nutrients and their use in the production of fertilisers can contribute to the circular economy. Efficient extraction of plant nutrients from "waste" could become part of renewable local fertilisers, ensuring more sustainable agricultural practices and food security. The idea of the project was to optimise the recovery process of extracting plant nutrients from simulated anthropogenic wastewater and biomass combustion ash under *ex-situ* conditions. It was found that almost 50% Ca, > 60% Mg, > 30% K, and about 25% P existing in biofuel ash could be extracted and used for the synthesis of sustainable fertilisers under the influence of different agents.



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▲ **Figure 11.** Plant nutrient extraction (%) from biofuel ash

2. New methods of extracting valuable substances from algae grown in complex multitrophic aquaculture (ExtraIMTA).

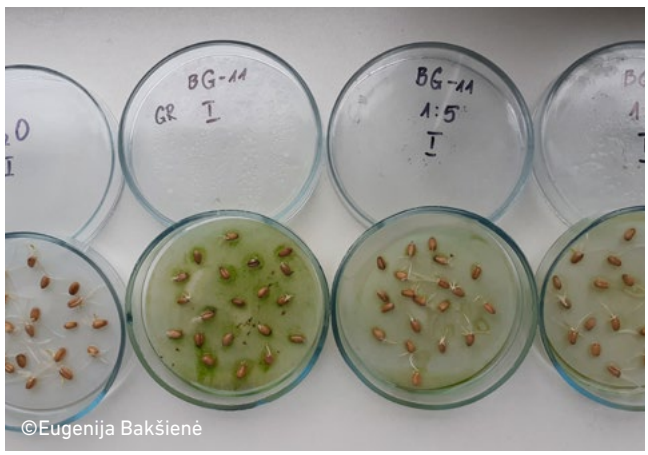
Project coordinators: Dr Arūnas Stirkė (FTMC),
Dr Eugenija Bakšienė (LAMMC),
Dr Liutauras Marcinauskas (LEI).
8 February–8 December, 2021.

The aim of the project was to bring together an interdisciplinary scientific team to develop sustainable solutions for integrated multitrophic aquaculture (IMTA). Objectives: (1) to develop advanced and waste-free technological platforms for land-based and maritime IMTA systems, (2) selection of new potential microalgae species suitable for sustainable IMTA in Lithuania, (3) to develop integrated methods / technologies for the extraction of valuable marine and freshwater algae compounds and the treatment of wastewater generated, (4) to evaluate and utilise the generated waste in the agricultural sphere by developing a circular IMTA technological process, and (5) to investigate the influence of microarrays on germination energy, germination, and development of various agricultural plant seeds.

Four types of microalgae (*Chlorella vulgaris*) (BG-11, PEF, N1, N2) grown and treated differently were used to study the germination energy and development of spring wheat, rye, fodder beans, and radish seeds in the experiment.

The effect of microalgae products on seed germination energy was different and depended on the chemical composition of the product, dilution concentration, and plant biological properties.

The germination energy was further increased (12–14%) by different concentrations of N1 and N2 using lower concentrations (1: 5 and 1:10) and PEF (1:10). The development of plants in the initial stages was positively affected by the products PEF, N1, and N2. Depending on the concentration of the solution, the leaf length increased by 5–8% compared to the control (distilled water). The effect on plant root length was smaller. Plants grown in PEF 1:10 and N1 1: 5 had significantly longer roots.



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▲ Effect of different algae bioproducts on the germination of spring wheat seed

3. Development of biodegradable biofuel cells (BioDegra).

Project coordinators:
Prof. Dr habil. Arūnas Ramanavičius (FTMC),
Dr Monika Vilkienė (LAMMC), Dr Nerijus Striūgas (LEI).
8 February–8 December, 2021.

The aim of the project was to create an anode for biodegradable biofuels using biochar from macrophytes (*Cladophora* spp.) and rhizobium bacteria (*Rhizobium* spp.). The formation of large-area, low-cost and biodegradable electrodes would allow them to be placed in soil to generate a sufficient amount of electricity and then decompose without leaving polluting decomposition products. For the manufacture of such electrodes, the use of biochar was envisaged, which could be used as a fertiliser in agriculture and would not harmthe environment. The use of such electrodes would solve other ecological problems in parallel, such as the eutrophication of the Baltic Sea and the accumulation of macrophytes on the coast. By reducing accumulation of macrophytes, the amount of accumulated atmospheric CO_2 that is trapped in the macrophyte biomass would also be eliminated. Carbon electrodes are often formed using a variety of environmentally harmful chemical binders, but this project involved the production of carbon electrodes by binding carbon of plant origin binders, which are widely used in the food and cosmetics industries, but the physical and chemical properties of these binders are still poorly used in energy. The study was to determine the required level of carbonization of the material in the formed electrodes, ensuring sufficient electrical conductivity, mechanical resistance, and aspects of their biodegradation.

▲ Collection of macroalgal biomass in the Baltic Sea for the production of biofuel cells

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8.4. PLANT BREEDING

The LAMMC conducts breeding programmes for the major field crops, vegetables, pomefruits, stonefruits, and berries. In 2021, the following **14** varieties were included in the National List of Plant Varieties: winter wheat 'Eldija', 'Sarta', 'Vaiva', small naked oat 'Milija DS', field pea 'Egle DS', 'Lina DS', narrow-leaved lupin 'VB Melsviai', 'VB Rausviai', smooth bromegrass 'VB Galinda', red fescue 'Raudys', gherkin 'Roliai', onion 'Joriai', strawberry 'Mera', 'Neda'. Thirteen species were included in the EU Common Catalogue of Varieties of Agricultural Plant Species.

A total of **131** varieties of agricultural plants bred at the LAMMC are currently included in the Lithuanian National List of Plant Varieties and the EU Common Catalogue of Varieties of Agricultural Plant Species.

Winter wheat 'Eldija'

Breeders: Assoc. Prof. Dr Vytautas Ruzgas, Dr Žilvinas Liatukas

The winter wheat variety 'Eldija' was developed at the Institute of Agriculture, LAMMC. The average grain yield was 7.5 t ha^{-1} in the official state variety testing during 2018–2020. It is a new type amylopectin wheat developed for production of special starch; its flour can be used for other special needs. The hectolitre weight was 793 g l^{-1}, 1000 kernel weight 37 g, amylopectin content over 99%.

The variety is characterised by high tolerance of cold, medium short plants, medium resistance to lodging, medium resistance to grain pre-harvest sprouting. The variety is susceptible to leaf spot diseases and *Fusarium* head blight, medium resistant to snow mould and powdery mildew, and resistant to leaf rust.

The recommended sowing time is the second half of September. Moderately intensive fertilisation and intensive pesticide application are recommended for its cultivation in fertile soils. Its cultivation is not recommended after wheat and other cereals due to possible grain contamination.

Winter wheat 'Sarta'

Breeders: Assoc. Prof. Dr Vytautas Ruzgas, Dr Žilvinas Liatukas

The winter wheat variety 'Sarta' was developed at the Institute of Agriculture, LAMMC. The average grain yield was 7.16 t ha^{-1} in the official state variety testing during 2018–2020. It is a new type, white grained amylopectin wheat developed for production of special starch; its flour can be used for other special needs. The hectolitre weight was 782 g l^{-1}, 1000 kernel weight 37.1 g, amylopectin content over 99%. The variety is characterised by high tolerance of cold, medium short plants, medium resistance to lodging, and medium susceptibility to grain pre-harvest sprouting. The variety is susceptible to leaf spot diseases and *Fusarium* head blight, medium resistant to snow mould and powdery mildew, and resistant to leaf rust. The recommended sowing time is the second half of September. Medium intensive fertilisation and intensive pesticide application are recommended for its cultivation in fertile soils. Its cultivation is not recommended after wheat and other cereals due to possible grain contamination.

Winter wheat 'Vaiva'

Breeders: Assoc. Prof. Dr Vytautas Ruzgas, Dr Žilvinas Liatukas

The winter wheat variety 'Vaiva' was developed at the Institute of Agriculture, LAMMC. According to grain quality traits, the variety belongs to extra quality group. The average grain yield was 9.36 t ha^{-1} in the official state variety testing during 2018–2020. Grain quality traits under intensive cultivation correspond to extra or 1st grain quality class standards. The average protein content was 12.7 %, sedimentation 43.6 ml, gluten 24.7%, 1000 kernel weight 47.9 g, and hectolitre weight 787 g l^{-1}.

The variety is characterised by high tolerance of cold, short plants, high resistance to lodging, and medium resistance to grain pre-harvest sprouting. It is medium susceptible to leaf spot diseases and leaf rust, but medium resistant to *Fusarium* head blight, stripe rust, snow mould, and powdery mildew. The recommended sowing time is the second half of September. Intensive fertilisation and pesticide application are recommended for its cultivation in fertile soils.


©Vida Danytė

Oat ‘Milija DS’

Breeders: Dr Vida Danytė, Dr Andrii Gorash

The oat variety ‘Milija DS’ was developed at the Institute of Agriculture, LAMMC. The variety was registered in Lithuania in 2021. The yield at Kaunas PVTD (Plant Variety Testing Division) was 7.27 t ha^{-1}. In 2019–2020, at PVTDs in Plungė, Kaunas and Kaišiadoriai , the average yield was 5.49 t ha^{-1}, plant height 94 cm, growing period 81 days. Grain contains, on average, 15.7% of protein and 7.2% of fat. In 2019, at Kaunas PVTD, the average hectolitre weight was 660 g l^{-1} and the highest was 708 g l^{-1}. The average thousand grain weight was 28.1 g, husk content 3.6%. It is resistant to loose smut, moderately resistant to crown rust and leaf blotch. In an especially unfavourable year 2019, at Jogeva Plant Breeding Station of the Estonian Crop Research Institute, the average yield was 4.75 t ha^{-1}, hectolitre weight 588 g l^{-1} and husk content 3.4%.


©Kristyna Razbadauskiene

Pea ‘Egle DS’

Breeder Kristyna Razbadauskienė

The pea variety ‘Egle DS’ was developed at the Institute of Agriculture, LAMMC, using a conventional pedigree method, by crossing two semi-leafless varieties ‘Grafila’ and ‘Respect’. Its value for cultivation and use (VCU) was tested during 2019–2020 by the State Plant Service under the Ministry of Agriculture in PVTDs in Kaunas, Pasvalys, and Utena. The test for distinctness, uniformity, and stability (DUS) was performed in Poland at Plant Variety Testing Centre. The mean seed yield was 6.11 t ha^{-1}. The highest seed yield of 7.99 t ha^{-1} was recorded in 2020 in Kaunas PVTD. The average thousand grain weight was 314.4 g, growing period 93.5 days. The grains mature 3–5 days later compared to the standard varieties. Plant height is 98.9 cm, resistance to lodging 8.5 scores, resistance to grain shattering 9 scores (1 – susceptible, 9 – resistant), protein content 23.8%. The variety is resistant to root and leaf diseases. ‘Egle DS’ is high yielding and late ripening variety, has long stems but is resistant to lodging.


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Pea ‘Lina DS’

Breeder Kristyna Razbadauskienė

The pea variety ‘Lina DS’ was developed at the Institute of Agriculture, LAMMC, using a conventional pedigree method, by crossing two semi-leafless varieties ‘Respect’ and ‘Audit’. Its value for cultivation and use (VCU) was tested during 2019–2020 by the State Plant Service under the Ministry of Agriculture in PVTDs in Kaunas, Pasvalys, and Utena. The test for distinctness, uniformity and stability (DUS) was performed in Poland at Plant Variety Testing Centre. The mean seed yield was 5.67 t ha^{-1}. The highest yield of 7.34 t ha^{-1} was recorded in 2020 in Kaunas PVTD. The average thousand grain weight was 285.7 g, growing period 90.8 days, plants height 85.6 cm, lodging resistance 8.0 scores, resistance to grain shattering 9 scores (1 – susceptible, 9 – resistant), protein content 23.2%. The variety is resistant to root and leaf diseases. ‘Lina DS’ is characterised by a medium growing period and produces a stable seed yield not only under conventional and but also under organic production system.


©Zita Maknickiene

Narrow-leaved lupin ‘VB Melsviai’

Breeders: Dr Zita Maknickienė, Dr Almantas Ražukas

The narrow-leaved lupin variety ‘VB Melsviai’ was developed at the Vokė Branch of the Institute of Agriculture, LAMMC. The variety is suitable for growing as green manure.

The average seed yield is 2.8–3.3 t ha^{-1}, (biological yield – 3.7–4.2 t ha^{-1}), green mass yield exceeds 60 t ha^{-1} depending on the crop density and meteorological conditions. It is better suited for more fertile soils due to the abundant branching. ‘VB Melsviai’ is resistant to drought and fungal diseases. It is an early variety with a growing period of 77–88 days.

The inflorescence is blue; the raceme consists of 18–28 flowers. The pod contains 3–5 seeds, or up to six in exceptional cases. The seeds are mottled, bright, with a brown base with white spots. A thousand seed weigh is 140–180 g.


©Zita Maknickiene

Narrow-leaved lupin 'VB Rausviai'

Breeders: Dr Zita Maknickienė, Dr Almantas Ražukas

The narrow-leaved variety 'VB Rausviai' was developed at the Vokė Branch of the Institute of Agriculture, LAMMC. It is a low-alkaloid variety with good nutritional properties: alkaloid content 0.011%, protein –30.3%, fat 6.4%. The seeds are rich in micro and macro elements, have a high content of essential amino acids, especially methionine 1.38% and histidine 9.27%.

The average seed yield is 2.8–3.5 t ha^{-1}. It is better suited for more fertile soils due to abundant branching. 'VB Rausviai' is resistant to drought and fungal diseases. It is an early variety with a growing period of 82–90 days. The inflorescence is of light pink colour, the raceme consists of 15–25 flowers, 6–12 pods are formed, 3–27 pods are formed on the lateral shoots depending on the number of lateral shoots. The pod contains 3–5 seeds. The seeds are mottled, with grey base with brown and white spots. A thousand seed weight is 165–180 g.


©Rita Asakavičiūtė

The smooth brome 'VB Galinda'

Breeders: Dr Rita Asakavičiūtė, Dr Almantas Ražukas
(this variety was derived from the variety 'Galinda' bred by Dr Jonas Šedys)

The smooth brome (B*romopsis inermis* (Leys.) Holub.) 'VB Galinda' was developed at the Vokė Branch of the Institute of Agriculture, LAMMC, by the method of mass selection from the local form of smooth brome of the Pomeranian region, Russia, obtained from the Nikolai Vavilov Institute of Crop Production. It is a fertile hay-type variety, characterised by rapid regrowth in spring and after cuts, resistant to lodging, stripe disease, wintering, and drought. The stems are tall, large, and leafy. It can grow in the same place for many years. The average yield of green mass is 45.4 t ha^{-1}, dry matter 11.3 t ha^{-1}. Absolutely dry matter has an average protein content of 11.8%. The average seed yield is 0.4 t ha^{-1}. The average plant height is 134 cm. A thousand seed weight is 3–4 g. The variety produces abundant dry matter and seed yield. It is resistant to lodging, cold, and spring frosts. The variety performs well in light soils and drained peatlands.


©Eglė Norkevičienė

Red fescue 'Raudys'

Breeder Dr Vaclovas Stukonis

'Raudys' is a red fescue variety developed at the Institute of Agriculture, LAMMC. It is productive, medium-early, and relatively resistant to diseases. Dry matter yield is 9.14 t ha^{-1}, the average plant height is 60 cm. A thousand kernel weight is 1.58 g. Foliage during inflorescence emergence was around 54.4%, crude protein content 13% and fibre 30.3% in dry matter.

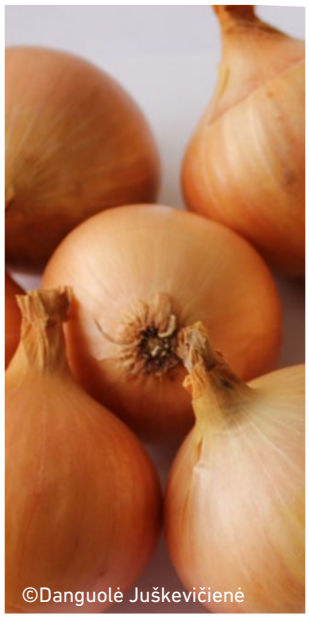
The variety is designed for pasture type meadows and landscape planting.


©Eugenijus Dambrauskas

Gherkin 'Roliai'

Breeder Dr Eugenijus Dambrauskas

'Roliai' is a parthenocarpic hybrid of cucumber (*Cucumis sativus* L.) developed at at the Institute of Horticulture, LAMMC. The hybrid is intended for growing in unheated greenhouses for a late spring-summer yield period. The yield can reach up to 14–16 kg m^{-2} when grown in the unheated plastic greenhouse. In the unheated glass greenhouse, the yield may be higher, ranging from 16 to 18 kg m-2 due to longer plant vegetation. The variety is suitable for growing in an open field, where the yield varies from 4 to 5 kg m^{-2}. The fruits have an intensive green colour without blackish shade and with light green stripes. They are suitable for fresh production and pickling.


©Danguolė Juškevičienė

Onion ‘Joriai’

Breeders: Dr Danguolė Juškevičienė, Dr Rasa Karklelienė

The onion variety ‘Joriai’ (*Allium cepa* L.) is a medium-early cultivar developed at the Institute of Horticulture, LAMMC. Plant vegetation lasts 90–110 days from seed germination. Onions can be propagated by seeds or onion sets. Intensive green-coloured foliage has 7–8 long and medium-wide leaves. The variety forms medium-sized bulbs weighing about 80–100 g. The bulb is covered with 5–6 medium-thick outer shells. The colour of outer shell is yellowish brown. The flesh of the bulb is white without discoloration in the epidermis. The shape of the bulb is flat round and rhombic in the longitudinal section. The average content of dry matter reaches 12–15%. The variety is distinguished by a very good storability.

The variety is suitable for growing for bulbs and fresh production and can be used for processing.


©Rytis Rugienius

Strawberry ‘Mera’

Breeder Dr Rytis Rugienius

The strawberry variety ‘Mera’ was developed at the Institute of Horticulture, LAMMC, by crossing the varieties ‘Irma’ and ‘Salut’. The plants are vigorous or moderately vigorous, forming a moderate number of runners. The leaves are large to medium in size, dark green, glossy, petioles are green. The inflorescences are at leaf level, berries are large. In Babtai, they were on average 19% larger than ‘Elkat’ berries. The berries are cone-shaped with a small neck, attractive, bright or dark red, the flesh is red and firm. The berries are delicious and aromatic. The variety blooms and ripens moderately early and is very productive: in Babtai, it was on average 20% more productive than the ‘Elkat’.

It is intended for fresh consumption and is also suitable for processing (jams, compotes).


©Rytis Rugienius

Strawberry ‘Neda’

Breeder Dr Rytis Rugienius

The strawberry variety ‘Neda’ was developed at the Institute of Horticulture, LAMMC, by crossing the cultivars ‘Sophie’ and ‘Arosa’. The plants are vigorous or moderately vigorous, forming a moderate number of runners. The leaves are large to medium in size, bright green, glossy, petioles are green. Inflorescences are at leaf level. The berries are large; in Babtai, they were on average 17% larger than ‘Elkat’ berries. They are cone-shaped with a small neck, attractive, bright red, flesh is red and firm. The berries are delicious, aromatic, and easy to pick. The variety blooms and ripens moderately late and is very productive. In Babtai, it was on average 24% more productive than the ‘Elkat’.

It is intended for fresh consumption and is also suitable for processing (jams, compotes).


©Rita Armonienė

9. RESEARCH INTERNSHIPS

The Agrifood Research and Technology Centre of Aragon, Spain

8 January–13 February. Dr Renaldas Žydelis, a researcher of the Department of Plant Nutrition and Agroecology at the Institute of Agriculture, LAMMC, undertook an internship at the Agrifood Research and Technology Centre of Aragon, Spain. **The aim of the internship** was to calculate water requirements of maize grown in the agroclimatic zone of Central Lithuania and to determine the optimal irrigation timing.

During the internship, the AquaCrop model was calibrated using the experimental data obtained from the maize experiments performed in 2015–2017 and 2019 in Lithuania. The data contained biomass and grain yield, leaf area, soil moisture variation at different depths, soil water holding capacity characteristics, detailed soil profile descriptions, and other experimental results that best reflected maize vegetation during the years of research.

The model, which was optimised to the Lithuanian agroclimatic zone and the tested maize variety, was used to calculate water requirements during the maize vegetation period, and the optimal irrigation timing was determined considering the needs of the plant.

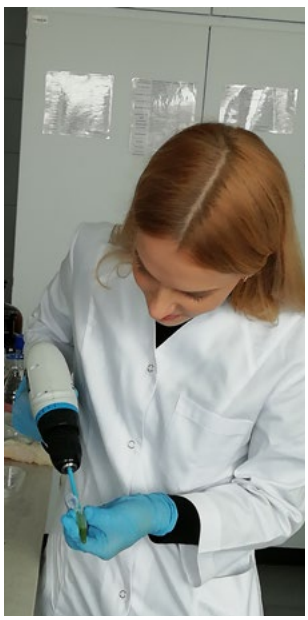
The project was funded by the EU Structural Funds under Measure No. 09.3.3-LMT-K-712 "Development of competences of scientists, other researchers and students through practical scientific activities".

The University of Agriculture in Krakow, Poland

1 February–26 March. Dr Viktorija Vaštakaitė-Kairienė, a senior researcher at the Laboratory of Plant Physiology of the Institute of Horticulture, LAMMC, conducted a research study at the Department of Botany and Plant Physiology of the University of Agriculture in Krakow (Poland). In co-operation with Dr Anna Kołton, a researcher at this university, Dr V. Vaštakaitė-Kairienė analysed the action of the enzyme responsible for nitrogen uptake in plants. She studied the mechanism of action of the nitrate reductase enzyme, which is responsible for nitrogen uptake and production of toxic nitrites in plants. Tomato seedlings were selected as model plants. The study was performed *in vitro*. The activity of nitrate reductase enzyme is known to increase due to the dephosphorylation reaction performed by the protein phosphatase 2 A (PP2A). In the study, the researcher used different concentrations of the pharmacological phosphatase inhibitor, okadaic acid, to gain more knowledge about the action of PP2A and phosphorylation/dephosphorylation reactions in plants. Also, the researcher evaluated the effect of calcium on PP2A activity when the inhibitor was used. Based on the results of the research, a scientific publication was prepared for an international journal.

This project received funding from European Social Fund (project No 09.3.3.-LMT-K-712-21-0056) under grant agreement with the Research Council of Lithuania (LMTLT).

▲ Dr Renaldas Žydelis and Dr Ramon Isla

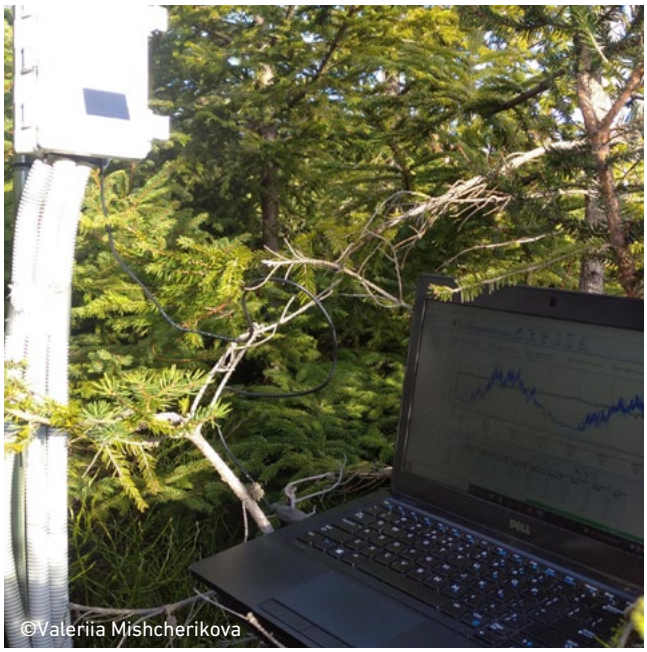


▲ Dr Viktorija Vaštakaitė-Kairienė at the University of Agriculture in Krakow

▲ Growing tomato seedlings *in vitro*

17 October–5 December. Valeriia Mishcherikova, a doctoral student at the Department of Forest Protection and Game Management of the Institute of Forestry, LAMMC, undertook an internship at the University of Agriculture in Krakow. **The aim of the internship** was to assess how climate change would affect the microorganism community of *P. sylvestris* and *P. abies* under different scenarios of climate change. During the internship, the doctoral student learned to select appropriate models for the analysis of microbial community data (tissues and soil), soil properties, and environmental parameters.

Valeriia Mishcherikova, a doctoral student, Marian Knapek, head of the Węgierska Górka Forestry Authority (*left*), and the University of Agriculture and Dr. Michal Jasik, Forestry in Krakow, a researcher at the Department of Forestry, the University of Agriculture in Krakow



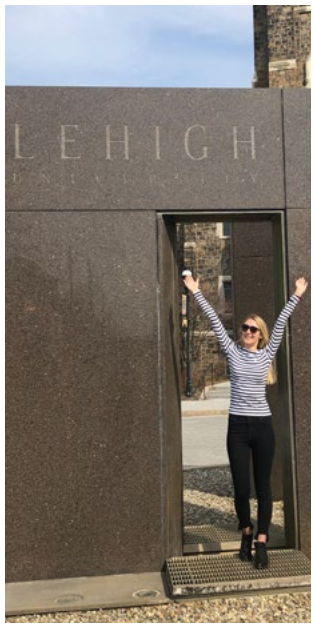
Data logger used for research in the forestry enterprise

Lehigh University, USA

1 February–30 March. Dr Donata Drapanauskaitė, a junior researcher at the Agrochemical Research Laboratory of the LAMMC, undertook an internship at Lehigh University, Bethlehem, USA. The aim of the internship was to develop competences in a scientific internship with the aim of developing new, environmentally-friendly nitrogen fertiliser by mechanosynthesis. During the internship, the junior researcher improved her theoretical knowledge and practical skills in the field of mechanosynthesis. She learnt how to produce nitrogenous fertiliser by mechanosynthesis, by changing the ratio of the milling materials. Subsequently, she analysed the resulting fertiliser using a Raman spectrometer with a confocal microscope and ion chromatography. She also further developed her scientific expertise. This project received funding from the European Social Fund (project No 09.3.3-LMT-K-712-21-0080) under grant agreement with the Research Council of Lithuania (LMTLT).

10 May–12 November. Dr Donata Drapanauskaitė, a researcher at the Agrochemical Research Laboratory of the LAMMC, undertook a postdoctoral internship at Lehigh University, Bethlehem, USA. **The aim of the internship** was to obtain urea compounds calcium and magnesium without the use of solutions. During the internship, the researcher mastered the solvent-free method to obtain four calcium, magnesium, and urea compounds. The physical and chemical properties of the compounds were also studied: their equilibrium solubility and urea release were determined. During the postdoctoral studies, diffractive X-ray analysis was mastered to check the quality of the obtained compounds.

The postdoctoral research was funded by Lehigh University.

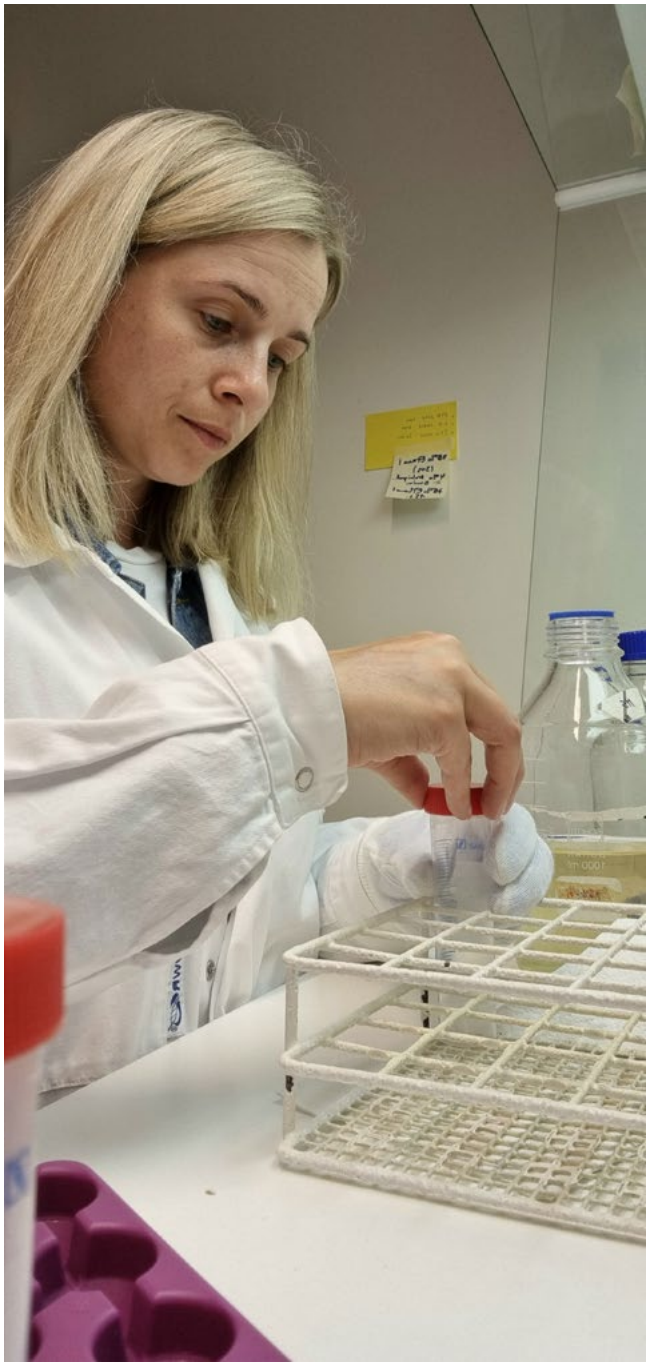


Dr Donata Drapanauskaitė at Lehigh University, USA

X-ray diffractometer, Lehigh University, USA

Swedish University of Agricultural Sciences (SLU)

2–30 June. Dr Diana Marčiulynienė, a senior researcher at Forest Protection and Game Management Department of the Institute of Forestry, LAMMC, did an internship in Sweden (Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences (SLU), in the framework of the ongoing project "Dynamic changes and restoration of soil properties, fungal and insect communities following clearcutting and biomass utilization in pine ecosystems". During the internship, molecular analysis of samples collected in Lithuania and preparation of samples for sequencing were performed. Dr Marčiulynienė became acquainted with new methods of detection and identification of fungal pathogens.



▲ Dr Diana Marčiulynienė's traineeship at the Swedish University of Agricultural Sciences

INRAE Bordeaux-Aquitaine Research Institute, France

12 June–28 August. Gabija Vaitkevičiūtė, a junior researcher and PhD student at the Laboratory of Genetics and Physiology of the Institute of Agriculture, LAMMC, did an internship at INRAE Bordeaux-Aquitaine research institute in Bordeaux, France. The metabolic phenotyping infrastructure "HiTMe" was used to carry out metabolite analyses for the project "Metabolite profiling in winter wheat during cold acclimation, deacclimation and reacclimation" and for her PhD research.

During the internship, ethanolic and acidic extractions of wheat samples were carried out and optimisations for the metabolite assays were executed. Subsequently, biochemical analyses of wheat leaf and crown region samples were carried out to quantify soluble carbohydrates, starch, proteins, redox metabolites, amino acids, and organic acids. Further possibilities regarding experiments to assess the change in metabolic profiles of varyingly freezing-tolerant winter wheat genotypes during cold acclimation were discussed.

The project was funded by EPPN2020//Transnational access.

▲ Optimisation of glucose, fructose and sucrose for their quantification in winter wheat leaves

▲ Prepared samples of ethanolic extracts of winter wheat leaves

ARGANS research company, France

16–31 July. Dr Valda Araminienė, a senior researcher at the Department of Silviculture and Ecology of the Institute of Forestry, LAMMC, undertook a scientific visit at ARGANS research company in France.

The collaboration between researchers from the two countries aims to quantify the role of current forest cover in cities and assess the impact of urban forests on air quality.

During the visit, two scientific publications were prepared.

The visit was part of Lithuanian-French programme "Gilibert" for Bilateral Cooperation (No. S-LZ-21-3).

▲ Dr Valda Araminienė's internship in ARGANS company, France

The Institute of Plant Physiology and Genetics of the Bulgarian Academy of Sciences

3 September–2 October. Dr Viktorija Vaštakaitė-Kairienė, a senior researcher at the Department of Plant Physiology of the Institute of Horticulture, LAMMC, had an internship at the Institute of Plant Physiology and Genetics of the Bulgarian Academy of Sciences (Sofia), working on the postdoctoral project "Influence of light and dark conditions on photophysiological response and production of leafy vegetables in closed-system horticulture" in collaboration with the Nature Research Centre (Lithuania). During the internship, the researcher deepened her knowledge of molecular biology methods used to determine the expression levels of genes encoding key antioxidant enzymes using common polymerase chain reaction (PCR) and real-time PCR analyses. Also, the researcher mastered staining methods for detecting lesions caused by active oxygen forms in plants in situ. The international co-operation will be continued with the application for a research project.

▲ Dr Viktorija Vaštakaitė-Kairienė's traineeship in the Institute of Plant Physiology and Genetics of the Bulgarian Academy of Sciences

This project received funding from European Social Fund (project No 09.3.3.-LMT-K-712-19-0101) under grant agreement with the Research Council of Lithuania (LMTLT).

The French National Research Institute for Agriculture, Food, and Environment (INRAE)

5–19 September. Modupe Doyeni, a doctoral student and junior researcher at the Laboratory of Agrobiology of the Institute of Agriculture, LAMMC, did an internship at the French National Research Institute for Agriculture, Food, and Environment (INRAE), France, for **the purpose** of learning and discussing new and improved methods of enzymatic analysis for microbial metabolism. This was part of the EJP soil (*towards climate-smart sustainable management*) objectives to improve the understanding of agricultural soil management by targeting: climate change mitigation and adaptation, food security, and ecosystem services and soil education in Europe and capacity building. During the internship, enzymatic laboratory analyses such as dehydrogenase, phosphatase, B-galactosidase, phenol oxidase, urease used to determine anthropogenic effects on the activities of soil microbes were carried out. The experience gained was immense, and the scientific visit would help to make the desired plans and improvement in future methodologies while undergoing this enzymatic assay. The scientific visit laid a good foundation to build-on as regards future scientific collaboration between INRAE and LAMMC.

▲ Enzyme analysis in a laboratory

▲ Modupe Doyeni, a doctoral student (*third left*), with the team of the Biochem-Env laboratory at INRAE, France

Aarhus University, Denmark

13–26 September. Aušra Bakšinskaitė, a PhD student in Agronomy Sciences at the LAMMC, did an internship at the Department of Agroecology of Aarhus University, Denmark. In co-operation with the Department of Agroecology, the EJP SOIL "Visiting Scientist Support - 1st Call" programme was implemented, which **aims** to strengthen co-operation of researchers across Europe. The main goal of the internship was to master the methods for determination of nitrogen and carbon isotope migration in plants and soil, which would also be applied in her PhD research, her dissertation topic being "Optimisation of yield and quality of agricultural crops using natural resources".

Throughout the visit, the PhD student was supervised by Prof. Dr Jim Rasmussen, who also introduced her to the group of researchers involved in the EJP SOIL project: Dr Zhi Liang, Dr Chiara De Notaris, Dr Kirsten Enggrob, Dr Esben Oster Mortense and Dr Leanne Elizbeth.

▲ Aušra Bakšinskaitė, a doctoral student, and Prof. Dr Jim Rasmussen

28 September–29 October. Karolina Verikaitė, a PhD student at the Department of Plant Pathology and Protection of the Institute of Agriculture, LAMMC, had an internship at the Department of Agroecology of Aarhus University, Denmark. During the internship, the student was supervised by Dr Thies Marten Heick and research related to doctoral studies was carried out (dissertation topic "*Zymoseptoria tritici* spread, pathogenicity and damage to winter wheat").

The aim of the internship was to master methods used to determine the sensitivity of the fungus *Z. tritici* to fungicides and the frequency of mutations that determine it. Isolates of the *Z. tritici* were isolated from leaf samples imported from Lithuania, and *in vitro* tests on the sensitivity of *Z. tritici* to fungicides were performed. The doctoral student also delved into the determination of the frequency of mutations leading to fungicide resistance in the *Z. tritici* population using polymerase chain reaction (PCR) and real-time PCR analyses.

The collaboration will continue with the preparation of an article on the research topic.

▲ Preparation for testing fungicidal susceptibility of the pathogen *Zymoseptoria triticito*

Aristotle University of Thessaloniki, Greece

16 September–19 October. Dr Rita Verbylaitė, a researcher at the Department of Genetics and Breeding of the Institute of Forestry, LAMMC, had an internship at the Laboratory of Forest Genetics and Tree Breeding of the Faculty of Agriculture, Forestry and Natural Environment, Aristotle University of Thessaloniki, Greece. **The aim of this internship** was to collect samples in the southernmost black alder populations in Europe in order to compare the level of genetic diversity between the Lithuanian and Greek populations and to determine the initial level of diversity in the central and marginal populations of this species. During the internship, Dr Rita Verbylaitė gained experience and knowledge from Prof. F. A. Aravanopoulos, the pioneer of forest genetic monitoring system, who presented the latest achievements, challenges, and first results of the forest genetic monitoring system that is currently being developed. During the internship, Greek black alder populations were intensively surveyed and samples for molecular assessment were collected (Lake Zazari and Chromatidis, Natura 2000 sites).

The internship was implemented as part of the project (No. 09.3.3-LMT-K-712-19-0093), funded by the European Social Fund under a grant agreement with the Research Council of Lithuania (LMTLT).

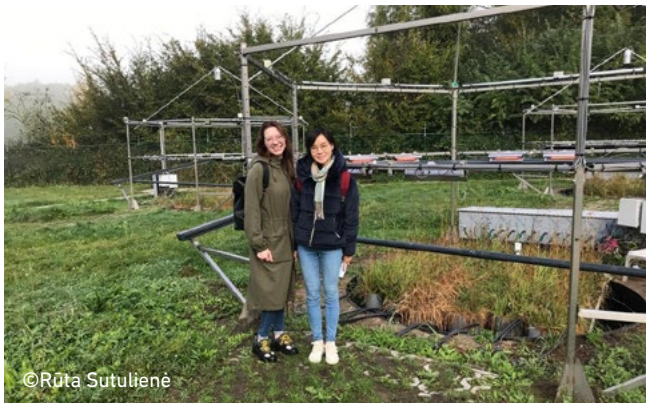
▲ Black alder sampling in the vicinity of Lake Zazari: Dr Rita Verbylaitė, Prof. Dr Filippos A. Aravanopoulos, and doctoral students Vasiliki Maria Kotina and Nikolas Tourvas

University of Antwerp, Belgium

20 September–22 October. Rūta Sutulienė, a junior researcher at the Laboratory of Plant Physiology of the Institute of Horticulture, LAMMC, did an internship at the Department of Biology, University of Antwerp, Belgium. The research work for the project "The potentialities of metallic nanoparticles application for leafy greens: biophysiochemical response and risk assessment" (NANOGREENS) was carried out. During the internship, the researcher learned to perform analyses with a microplate reader. Determination of total protein, polyphenols, flavonoids, as well as determination of total soluble and insoluble sugar, determination

of lipid content and analyses of proline and FRAP were mastered. The Ecotron system, consisting of 12 lysimeters, was also visited. The system can be used to grow grasslands or crops under different conditions, as each lysimeter has a separate automated irrigation system and rain protection.

This internship was funded by project No. S-MIP-21-27.



▲ Doctoral student Rūta Sutulienė (*left*) at the Ecotron lysimeter system

The Institute of Food Safety, Animal Health and Environment "BIOR", Latvia

7 October–5 November. Dr Sigita Janavičienė, a researcher at the Department of Plant Pathology and Protection of the Institute of Agriculture, LAMMC, did an internship at the Institute of Food Safety, Animal Health and Environment "BIOR" in Latvia. **The aim of the internship** was to deepen the knowledge of the quantitative and qualitative determination of mycotoxins using the chromatography system coupled to mass spectrometry (QqQ, Orbitrap, TOF, etc.).

In the Laboratory of Chemistry (Latvia), she was working on the postdoctoral project "Toxigenicity of *Fusarium graminearum* residing in alternative host-plants to wheat as influenced by the environmental conditions".

During the internship, the researcher delved into the construction and operating principles of liquid chromatography coupled with mass spectrometry (Thermo Scientific TSQ Quantiva MS/MS). Optimisation of chromatographic methods for quantitative and qualitative determination of mycotoxins in different matrices was performed. She mastered the principles of preparation, calculation, and identification of samples with extremely high concentrations of mycotoxins and gained practical knowledge on chromatogram analysis and interpretation. During the internship, the researcher improved her qualification as a researcher in the field of chromatography.

▲ Dr Sigita Janavičienė and Prof. Dr Vadims Bartkevičs

The internship laid the foundation for further international co-operation between BIOR and the LAMMC.

This project received funding from the European Social Fund (project No 09.3.3-LMT-K-712-19-0084) under grant agreement with the Research Council of Lithuania (LMTLT).

Wrocław University of Environmental and Life Sciences, Poland

3 November–2 December. Dr Karolina Barčauskaitė, a senior researcher and head of the Agrobiology Laboratory undertook an internship at Wrocław University of Environmental and Life Sciences, Poland. She carried out research under the ongoing postdoctoral fellowship project "Influence of agrotechnological measures on the phytochemical composition of fibrous hemp (*Cannabis sativa* L.) in morphological parts of the plant".

During the internship, the researcher performed investigations on secondary metabolites in fibre hemp leaves and inflorescences. The profile of volatile compounds, the composition of essential oils, the content of cannabinoids and the qualitative and quantitative analysis of fatty acids were carried out. The researcher improved her analytical skills in GC-MS. The obtained results will be publicised in joint publications.

This project received funding from the European Social Fund (No 09.3.3.-LMT-K-712-19-0132) under the grant agreement with the Research Council of Lithuania (LMTLT).

▲ Dr Karolina Barčauskaitė analyses the data obtained during her traineeship

Natural Resources Institute Finland (Luke)

14–27 November. Dr Valda Gudynaitė-Franckevičienė, a junior researcher at the Institute of Forestry, LAMMC, deepened her professional knowledge at the Natural Resources Institute Finland (Luke), Joensuu unit. Under the leadership of Dr Timo Domisch, a researcher at the Natural Resources Institute, she was learning new methodologies for studying the ecogenetic and ecophysiological response of plants to various stressors, evaluating their role in short- and long-term adaptation to the effects of climate change.

This project received funding from the European Social Fund (project No 09.3.3-LMT-K-712) under a grant agreement with the Research Council of Lithuania (LMTLT).

©Eija Koljonen

▲ Dr Valda Gudynaitė-Franckevičienė's traineeship at the Natural resources Institute Finland in Joensuu


©Gintarė Naujokienė

10. RECOGNITION OF RESEARCH ACTIVITIES

In 2021, scientists and PhD students of the LAMMC actively participated in research activities and did not go unnoticed: they were elected full members of the Lithuanian Academy of Sciences, were awarded with letters of appreciation and certificates of merit, and became winners of competitions and recipients of scholarships

Members of the Lithuanian Academy of Sciences

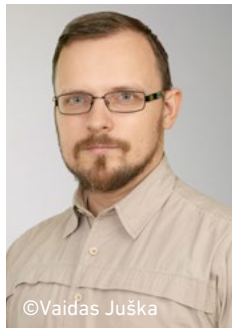
On 13 April, Dr **Giedrė Samuolienė**, Head of the Laboratory of Plant Physiology at the Institute of Horticulture of the LAMMC, and Dr **Kęstutis Armolaitis**, Chief Scientist of the Department of Ecology of the Institute of Forestry, became full members of the Lithuanian Academy of Sciences.

In December, Dr **Monika Toleikienė** and Dr **Jonas Viškelis** were elected new members of the Young Academy of the Lithuanian Academy of Sciences.

▲ Dr Giedrė Samuolienė

▲ Dr Kęstutis Armolaitis

▲ Dr Monika Toleikienė



▲ Dr Jonas Viškelis

Titles of the Lithuanian Agronomist of Merit and the Honorary Member of the Lithuanian Union of Agronomists

On 16 September, the Congress of the Lithuanian Union of Agronomists (LAS), celebrating its centenary, was held in Akademija in Kėdainiai district. The titles of Lithuanian Agronomists of Merit were conferred on LAMMC scientists Dr **Žydrė Kadžiulienė**, Dr **Audrius Sasnauskas**, and Dr **Virginijus Feiza**, and the title of the Honorary Member of the LAS was conferred on Dr **Irena Deveikytė**.

▲ Dr Irena Deveikytė, Dr Žydrė Kadžiulienė, and Dr Audrius Sasnauskas (*centre*)

▲ Dr Virginijus Feiza

Commendations

The President of the Republic of Lithuania awarded Prof. Dr **Pranas Viškelis**, an LAMMC scientist and a member of the Lithuanian Academy of Sciences, with the Officer's Cross of the Order of the Grand Duke Gediminas of Lithuania for his scientific achievements and innovations in the development of plant-derived food processing technologies and products.

On the occasion of the 70th anniversary of the Lithuanian Academy of Sciences, the academicians Assoc. Prof. Dr **Vytautas Ruzgas** and Prof. Dr **Pavelas Duchovskis** were honoured with commendations from the President of the Republic of Lithuania for their achievements in science and dissemination of these achievements among the younger generation, the academic community, and the general public.

Officer's Cross of the Order of the Grand Duke Gediminas of Lithuania

Prof. Dr Pranas Viškelis

Assoc. Prof. Dr Vytautas Ruzgas

Prof. Dr Pavelas Duchovskis

Prizes and Certificates of Merit

On 23 February, the Presidium of the Lithuanian Academy of Sciences decided to award prizes and certificates of merit to students, PhD students, and young scientists. Among the winners of the 2020 competition of research works by students in higher education organised by the Lithuanian Academy of Sciences were two master's students who conducted their research at the LAMMC: **Greta Striganavičiūtė** ("Studies into the effects of the hormone abscisic acid and its application in micropropagation of selected trees of the genus Populus", supervisor Dr Jonas Žiauka) and **Gabija Vaitkevičiūtė** ("Identification and analysis of new Sus1, Wx-B1 and Wx-D1 alleles in TILLING populations of winter wheat", supervisor Dr Rita Armonienė). In the Young Scientists and Doctoral Students Competition 2020, organised by the Lithuanian Academy of Sciences, a prize was awarded to Dr **Donata Drapanauskaitė**, a researcher at the Agrochemical Research Laboratory of the Institute of Agriculture, for her research paper "The influence of liming agents of different chemical composition and structure on the neutralization of acidic soil", supervisor Dr Romas Mažeika, consultant Dr Regina Repšienė. A certificate of merit was awarded to Dr **Kristina Bunevičienė**, a junior researcher at the Agrobiology Laboratory of the Institute of Agriculture, for her thesis "Quality of biofuel ash-based fertiliser products and their impact on soil and plants", supervisor Dr Romas Mažeika.

Greta Striganavičiūtė

Gabija Vaitkevičiūtė

Dr Donata Drapanauskaitė

Dr Kristina Bunevičienė

In February, Dr **Eugenija Bakšienė** was awarded the Jonas Kriščiūnas Prize in agricultural sciences, established by the Lithuanian Academy of Sciences, for her work "The use of lake sapropel for the fertilisation of soils with light granulometric composition".

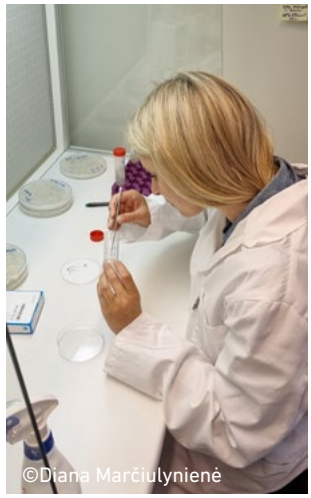
▲ Dr Eugenija Bakšienė

Scholarships

In 2020-2021, LAMMC scientists Dr **Diana Marčiulynienė**, research topic "Contamination of watersheds and rivers by plant pathogens", and Dr **Neringa Rasiukevičiūtė**, research topic "Innovative biocontrol methods for reduction of contamination of foodstuffs by essential oils and light emitting diodes", were awarded the National Fellowship Lithuania of the World Federation of Scientists (WFS).

In addition to the WFS Fellowship, in 2021 Dr **Diana Marčiulynienė** was awarded a NordGen Forest Fellowship, which is open to the researchers working or studying in the fields of forest seed or plant breeding, reforestation methods and tree breeding.

On 22 June, LAMMC scientists Dr **Viktorija Vaštakaitė-Kairienė**, research topic "Optimisation of artificial lighting for efficient nitrogen metabolism in plants", and Dr **Renaldas Žydelis**, research topic "Application of aerial data in predicting the barley yield, its quality and macronutrient uptake in low productivity soils", were awarded Young Scientists Scholarships of the Lithuanian Academy of Sciences for 2021–2022.



▲ Dr Diana Marčiulynienė

▲ Dr Neringa Rasiukevičiūtė

▲ Dr Viktorija Vaštakaitė-Kairienė

▲ Dr Renaldas Žydelis and Prof. Jūras Banys, President of the Lithuanian Academy of Sciences

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11. DISSEMINATION OF SCIENTIFIC KNOWLEDGE

In 2021, the LAMMC organised international and national events: conferences, seminars, training, and field days, both contact and remotely. The teleconference **"The EU's Farm-to-Table Strategy – Challenges and Opportunities for the Agro-Sector"** hosted by the scientific conference **"Agro-forestry Sciences: State-of-the-art Research Results and Innovative Solutions"**, was a major event for the scientific community and called on scientists to take into account the importance of a number of aspects in tackling the challenge of climate change: individual responsibility, scientific progress and the development of bioeconomy.

A great deal of interest was shown in the international European Green Week conference **"Towards zero pollution: Challenges and Prospects for Agriculture and Forestry"**, which analysed the initiatives of the European Green Deal in the areas of climate change, chemicals strategy, energy, industry, mobility, agriculture, fisheries, health and biodiversity. Along with organising events, publications were produced for the scientific community and the general public.

11.1. INTERNATIONAL CONFERENCES, SEMINARS, AND WORKSHOPS

In 2021, **3** conferences (**CYSENI 2021, "Towards Zero Emissions – Challenges and Prospects for Agriculture and Forestry"**, "**Dialogue on the Sustainable Use of Forest Landscapes for Wood for Energy and the Bioeconomy"**, **5** seminars, and **1** international workshop under the project WAMBAF ToolBox were organised. The most important international events are listed below.

23 February
Seminar under the international project "BAPR – Phytoremediation of the Baltic Sea Region".

4–5 March
Webinar "Better yields only in healthy soils" of the project "Sharing knowledge on best practices for maintaining healthy soils in Europe" (BEST4SOIL).

7 April
The LAMMC organised an **international training** under the project **"Water Management in Baltic Sea Region Forests ToolBox"** (WAMBAF ToolBox). Dr Olgirda Belova, the project coordinator in Lithuania, presented the book *Beaver as a renewable resource: A beaver dam handbook for the Baltic Sea Region*.

29 June
Remote **overview tour of the INTERREG project "Baltic Phytoremediation" (BAPR)** and a presentation of the evaluation of experimental/pilot studies.

12–13 and 26–27 October
Virtual **conference "Dialogue on Governance to Develop Sustainable Forest Landscapes for Production of Wood for Energy and the Bioeconomy"**.

1–4 June
Interactive European Green Week **virtual exhibition**, featuring an LAMMC stand.

24–28 May
International Conference of Young Scientists **CYSENI 2021** / **"Conference of Young Scientists on Energy and Natural Sciences Issues"**, organised jointly with the Lithuanian Energy Institute and the Center of Physical Sciences and Technology.

27 May
The LAMMC **International European Green Week Conference "Towards Zero Pollution – Challenges and Prospects for Agriculture and Forestry"**.

11.2. NATIONAL CONFERENCES, SEMINARS, AND FIELD DAYS

In 2021, **4** high-profile conferences, the discussion forum "More with Less", events for the 70th anniversary of the Institute of Forestry, and **10** seminars and field days were organised. The main national events of 2021 are given below. The LAMMC took an active part in the events organised by other institutions. The LAMMC participated in the virtual discussion "Become one of the changemakers" with agribusiness leaders at "VMU ŽŪA Karjeros dienos 2021" (Career Days 2021 of the Agricultural Academy, Vytautas Magnus University) and prepared a virtual stand to attract students. Dr Eglė Norkevičienė, Dr Vaclovas Stukonis, and doctoral student Vilma Živatkauskienė, of the Herb Breeding Department, and doctoral student Mindaugas Budvytis of Plant Nutrition and Agroecology Department introduced visitors to "Kvapų naktis" (The Night of Fragrancies), an event traditionally organised by the Botanical Garden of Vytautas Magnus University, to different species of grassland bryophytes. Scientists from the Biochemistry and Technology Laboratory of the Institute of Horticulture took part at the exhibition "Inno Panorama". Head of the Laboratory Prof. Dr Pranas Viškelis, doctoral student Lina Šernaitė-Dėnė, and doctoral student Paulina Štreimikytė presented the research carried out at the Open Access Centre for Modelling Fruit and Vegetable Processing Technologies of the LAMMC at the "Zero Waste" festival.

26–29 January
The LAMMC virtual scientific **conference "Agrarian and Forestry Sciences: State-of-the-art Research Results and Innovative Solutions"**, consisting of a **remote discussion "The EU Farm-to-Table Strategy: Challenges and Opportunities for the Agro-sector"** and a series of scientific seminars (27 January – on productivity and sustainability of agricultural and forest soils and horticultural technologies; 28 January – on bio-potential and protection of agricultural crops, and 29 January – on forestry and genetics and breeding).

9 February
Virtual **seminar of the project "Strengthening the IKOK Decisions on Crop Protection"** (IKOK Decisions).

19 March
Remote **conference "Digitalisation and Artificial Intelligence in Agriculture: From Idea to Practice"** to mark the Earth Day.

17 June
Conference of the Division of Agricultural and Forestry Sciences of the Lithuanian Academy of Sciences and the LAMMC **"The Green Course: Plant Nutrition and Fertiliser Reduction Aspects"**.

22 June
Publicity **seminar "Phytoremediation – a Green Technology for Remediation of Contaminated Soils"** of the "Baltic Phytoremediation Project" (BAPR) under the INTERREG programme at the Vėžaičiai branch of the Institute of Agriculture of the LAMMC.

1 July
Virtual discussion forum "More with less", organised by the Lithuanian Plant Protection Association (LAAA) and the LAMMC, focused on rational use of resources, innovative solutions and precision methods in crop production.

7 October
The **70th anniversary** of the Institute of Forestry of the LAMMC.

4 November
Webinar "Features of the Cultivation of Non-traditional Crops and New Varieties of Peas under Organic and Sustainable Farming Conditions".

9 December
Scientific **conference "Biomass Decomposed in Biogas Production: Waste or Secondary Products?"** organised together with Vytautas Magnus University.

10 December
Webinar "Soil Organic Carbon – the Key to Sustainability", under the project "Climate-Smart Management of Agricultural Soils" (EJP SOIL).

9 July
A **visit** of Kęstutis Navickas, minister of agriculture, to the LAMMC.

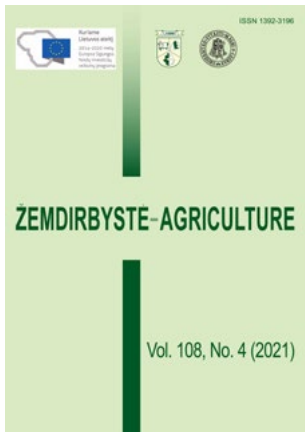
15 September
Publicity **seminar "Plant support for the remediation of contaminated soils"** of the project "Baltic Phytoremediation Project" (BAPR) under the INTERREG programme at the Vėžaičiai Branch of the Institute of Agriculture of the LAMMC. The seminar was attended by teachers and eighth-grade pupils from the Vėžaičiai Lower Secondary School (Klaipėda district).

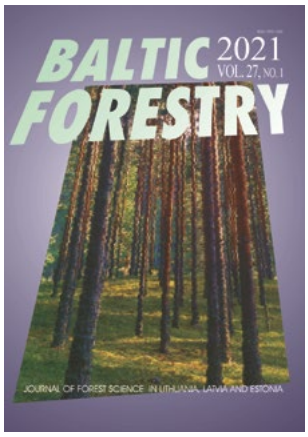
30 September
Field day-seminar "Exceptional plants" at organic rotation experimental fields of the Institute of Agriculture, LAMMC.

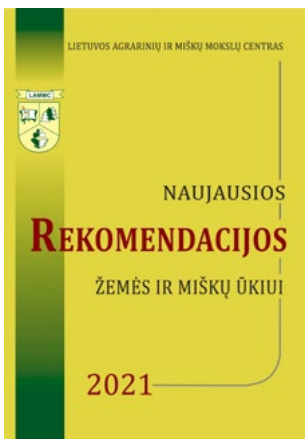
11.3. PUBLICATIONS

Together with partners, the LAMMC publishes the following scientific journals: *Zemdirbyste-Agriculture* (IF 2020/2021 – 0,722), *Baltic Forestry* (IF 2020/2021 – 0,722), and *Agronomy Research*.

The publishing of *Zemdirbyste-Agriculture* is supported by the project "Publishing of Periodical Scientific Publications and its Coordination" of the Lithuanian Academy of Sciences, which is funded by the EU Social Fund. Other publications issued in 2021: *Annual Report for 2020* and *The Latest Recommendations for Agriculture and Forestry*.



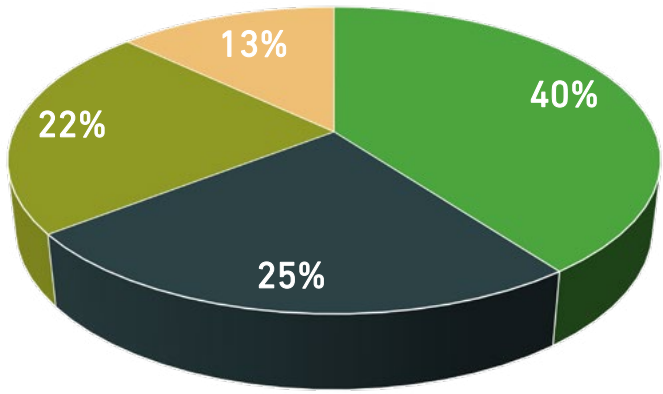




12. FUNDING

The budget of the LAMMC consists of state budget allocations, project financing revenues (received from national and international projects), funds from work outsourced to the LAMMC by Lithuanian and foreign entities, and other operating revenues (sales of agricultural products, lease of assets, etc.) (*Figure 12*).

In 2021, the revenue of LAMMC amounted to 13033.3 thousand euro.



▲ **Figure 12.** Sources of funding

The main costs in 2021 were: wages and social security contributions (70.8%), goods and services (16.3%). The remaining expenditure was allocated to utilities and communications, business trips, transport maintenance costs, professional development, scholarships for doctoral students, royalties, and other needs.

13. ANNEXES

13.1. INTERNATIONAL PROJECTS

"Horizon 2020" projects

1. "A holistic fire management ecosystem for prevention, detection and restoration of environmental disasters" (DRYADS). Project coordinator Dr Vaida Sirgedaitė-Šėžienė, Institute of Forestry. 2021–2025.
2. "Mechanisms underlying TRAde-offs between Carbon sequestration, greenhouse gas Emissions and nutrient losses in Soils under conservation agriculture in Europe" (TRACE-Soils). Project coordinator in the Institute of Agriculture Dr Dalia Feizienė. 2021–2024.
3. "Innovative soil management practices across Europe" (i-SoMPE). Project coordinator in the Institute of Agriculture Dr Lina Šarūnaitė. 2021–2022.
4. "Stimulating novel technologies from earth remote observation to predict European soil carbon" (STEROPES). Project coordinator in the Institute of Agriculture Dr Renaldas Žydelis. 2021–2024.
5. "Sensor data for downscaling digital soil maps to higher resolutions" (SensRes). Project coordinator in the Institute of Agriculture Dr Renaldas Žydelis. 2021–2024.
6. "Soil organic carbon sequestration potential of agricultural soils in Europe" (CarboSeq). Project coordinator in the Institute of Agriculture Dr Ieva Mockevičienė. 2021–2024.
7. "Stocktaking for agricultural soil quality and Ecosystem Services Indicators and their Reference values" (SIREN). Project coordinator in the Institute of Agriculture Dr Dalia Feizienė. 2021.
8. "Towards climate-smart and sustainable soil management" (EJP SOIL). Coordinator in the Institute of Agriculture Dr Žydrė Kadžiulienė, deputy coordinator Dr Virginijus Feiza. 2020–2024.
9. "Stepping-up IPM decision support for crop protection" (IPM Decisions). Coordinator in the Institute of Agriculture Dr Roma Semaškienė. 2019–2024.
10. "Best4Soil". Coordinator in the Institute of Agriculture Dr Antanas Ronis. 2019–2021.
11. "A thematic network to design the penetration path of non-food agricultural crops into European agriculture" (PANACEA). Coordinator in the Institute of Agriculture Dr Vita Tilvikienė. 2017–2021.
12. "Fostering sustainable legume-based farming systems and agri-feed and food chains in the EU" (LEGVALUE). Coordinator in the Institute of Agriculture Dr Žydrė Kadžiulienė. 2017–2021.

LIFE Programme Projects

1. "Demonstration of climate change mitigation potential of nutrient rich organic soils in Baltic States and Finland" (LIFE OrgBalt). Coordinator in the Institute of Forestry Dr Kęstutis Armolaitis. 2019–2023.
2. "Nutrient recycling circular economy model for large cities – water treatment sludge and ashes to biomass to bio-energy" (NutriBiomass4LiFE). Coordinator in the Agrochemical Research Laboratory Dr Lina Žičkienė. 2018–2022.

EUREKA Programme Project

1. "Developing of novel symbiotic functional drink with different plant-based fractions using *Medusomyces gisevii* culture". Coordinator in the Institute of Horticulture Prof. Dr Pranas Viškelis. 2020–2023.

Baltic Research Programme Project

1. "Improving adaptability and resilience of perennial ryegrass for safe and sustainable food systems through CRISPR-Cas9 technology" (EditGrass4Food). Project coordinator in the Institute of Agriculture Dr Kristina Jaškūnė. 2021–2024.
2. "NOBALwheat – breeding toolbox for sustainable food system of the NOrdic BALtic region". Project principal investigator Dr Gintaras Brazauskas. 2021–2023.
3. "Sustainable use of soil resources in the changing climate" (SUCC). Project coordinators: in the Institute of Forestry Dr Kęstutis Armolaitis, in the Institute of Agriculture Dr Jelena Ankuda. 2020–2023.

INTERREG Programme Projects

1. "Baltic Phytoremediation" (BAPR). Coordinator in the Vėžaičiai branch Dr Danutė Karčauskienė. 2019–2022.
2. "Water Management in Baltic Forests Tool Box" (WAMBAF). Coordinator in Lithuania Dr Olgirda Belova. 2019–2021.
3. "Market driven authentic Non-Timber Forest Products from the Baltic region – focus on wild and semi cultivated species with business potential" (NovelBaltic). Coordinator at Institute of Horticulture Dr Ramunė Bobinaitė. 2019–2021.

COST Actions

1. CA20132 "Urban Tree Guard – Safeguarding European urban trees and forests through improved biosecurity" (UB3Guard). Coordinator in the Institute of Forestry, Management committee member and leader of WG2 "Innovations" Dr Diana Marčiulynienė. 2021–2025.
2. CA19116 "Trace metal metabolism in plants" (PLANTMETALS). Coordinators in the Institute of Agriculture Dr Karolina Barčauskaitė, Dr Renaldas Žydelis. 2020–2024.
3. CA19125 "EPIgenetic mechanisms of crop adaptation to climate change" (EPI-CATCH). Coordinators in the Institute of Agriculture Dr Kristina Jaškūnė. 2020–2024.
4. CA18134 "Genomic biodiversity knowledge for resilient ecosystems" (G-BIKE). Coordinators in the Institute of Forestry Dr Olgirda Belova, Prof. Dr habil. Alfas Pliūra. 2019–2023.
5. CA18111 "Genome editing in plants – a technology with transformative potential" (PlantEd). Coordinators in the Institute of Horticulture Dr Danas Baniulis, Institute of Agriculture Dr Andrius Aleliūnas. 2019–2023.
6. CA18201 "An integrated approach to conservation of threatened plants for the 21st Century" (CONSERVE PLANTS). Coordinators in the Institute of Forestry: Dr Rita Verbylaitė, Dr Diana Lukminė. 2019–2023.

Projects of other research supporting EU programmes

1. Lithuanian–French Programme "Gilibert" for Bilateral Cooperation. "Impact of urban trees on air pollution and human health". Project coordinator in the Institute of Forestry Dr Valda Araminienė. 2021–2022.
2. "Collaborative action for updating the documentation about berry genetic resources in Europe" (EUROPE. BERRIES). Coordinator in the Institute of Horticulture Dr Rytis Rugienius. 2021.
3. Programme FACCE SURPLUS project "Biofortified and climate-resilient food and fodder production on marginal soils" (BioFoodOnMars). Project leader Dr Virmantas Povilaitis. 2020–2023. Support for international research and technology development projects funded by LR Ministry of Agriculture.
4. SNS (Nordic Forest Research Co-operation Committee) project "Conservation of resistant ash (*Fraxinus excelsior*) genotypes in Nordic and Baltic regions to maintain the full range of ecosystem-services provided by this keystone species". Coordinators in the Institute of Forestry Dr Diana Marčiulynienė, Prof. Dr habil. Alfas Pliūra. 2019–2022.
5. "Baltic Sea Region network for sustainable wheat production" (BALTICWHEAT). Coordinator at the Institute of Agriculture Dr Rita Armonienė. 2019–2021.
6. SNS (Nordic Forest Research Co-operation Committee) project "Preventing the spread of new pathogens in Nordic forests to secure sustainable forestry in growing bioeconomy". Coordinators in the Institute of Forestry Dr Diana Marčiulynienė. 2019–2021.
7. Inter-institutional collaboration project "Ash-Adapt – Evolutionary potential of natural *Fraxinus excelsior* populations challenged by novel pests and pathogens". Coordinator in the Institute of Forestry Dr Rita Verbylaitė. 2019–2021.
8. European Cooperative programme for Plant Genetic Resources project "Facilitating use on the European perennial ryegrass collection: improving access to genetic resources and C&E data". Coordinator in the Institute of Agriculture: Dr Eglė Norkevičienė (2018), Dr Gražina Statkevičiūtė (2019–2020), Dr Vilma Kemešytė. 2018–2022.
9. European Food Safety Authority (EFSA) project "European Network of Wildlife" (ENETWILD). Coordinator in the Institute of Forestry Dr Olgirda Belova. 2017–2023.
10. EUFORGEN: "The European Forest Genetic Resources Programme – VI". Coordinator in the Institute of Forestry Dr Virgilijus Baliuckas. Since 2010.
11. SNS (Nordic Forest Research Co-operation Committee) project "Northern European database of long-term forest experiments". Coordinator in the Institute of Forestry Dr Marius Aleinikovas. Since 2008.
12. "Winter wheat breeding, variety testing and marketing in Estonia". Coordinator in the Institute of Agriculture Assoc. Prof. Dr Vytautas Ruzgas. Since 2000.

13. "European plant genetic resources conservation programme". Coordinator in the Institute of Agriculture Assoc. Prof. Dr Vytautas Ruzgas. Since 1998.

13.2. NATIONAL PROJECTS

Research funded by the Research Council of Lithuania

Projects of researchers' teams

1. "The potentialities of metallic nanoparticles application for leafy greens: biophysiochemical response and risk assessment". Project leader Dr Jurga Miliauskienė. 2021–2024.
2. "Environmental and genotype impacts on plant exosome characteristics and potential applications for cosmetics and pharmacy". Project leader Dr Akvilė Viršilė. 2021–2024.
3. "Light as a tool of biofortification: photophysiological aspects of essential trace elements management in leafy vegetables". Project leader Dr Aušra Brazaitytė. 2019–2022.

Projects implemented by world-class researcher groups aimed at developing results in line with R&D topics relevant to the economic sectors which could then be commercialised, funded by the European Union funds

1. "Management of target metabolites of industrial hemp for the development of COVID-19 symptom relief products" (TerpenCoTech). Project leader Dr Vita Tilvikienė. 2021–2023.
2. "Biological plant protection strategies: boosting sustainability-orientated competitiveness in controlled environment horticulture". Project leader Dr Aušra Brazaitytė. 2020–2023.
3. "Development of wood modifying eco-friendly technology for higher value products". Project leader Dr Marius Aleinikovas. 2017–2021.
4. "Closed plant cultivation system for production of raw materials for peptide nanoengineering applications". Project leader Dr Danas Baniulis. 2017–2021.
5. "UV-A lighting strategies for controlled environment horticulture: upgrade to sustainable, high-value production". Project leader Dr Akvilė Viršilė. 2017–2021.
6. "Quality diagnostics of biogas production by-product (digestate) for innovative use as a biofertiliser". Project leader Dr Alvyra Šlepetienė. 2017–2021.
7. "Development of winter wheat varieties for amylose-free starch and vital gluten processing". Project leader Dr Gintaras Brazauskas. 2017–2021.
8. "Enhancement of the multifunctional properties of legumes in feed and food value chains" (SmartLegume). Project leader Dr Žydrė Kadžiulienė. 2017–2021.

Grant for high-level researchers group project

1. "Insights into future forests: challenges of climate change and diseases, and possible measures for saving biodiversity and ecosystem functioning". Project leader Dr Audrius Menkis. 2017–2022.

Post-doctoral internships in Lithuania

1. "Counteracting decline in biodiversity hotspots: conservation ecology and management of wood-inhabiting fungi in oak habitats". Research supervisor Dr Audrius Menkis, post-doc Dr Adas Marčiulynas. 2021–2023.
2. "Toxigenicity of *Fusarium graminearum* residing in alternative host-plants to wheat as influenced by the environmental conditions". Research supervisor Dr Skaidrė Supronienė, post-doc Dr Sigita Janavičienė. 2020–2022.
3. "Epigenetic and genetic variation of trees, ecogenetic plasticity and adaptation possibilities in climate change". Research supervisor Dr Alfas Pliūra, post-doc Dr Valda Gudynaitė-Franckevičienė. 2020–2022.
4. "Adaptation potential of Alnus glutinosa in future forests under climate change: genetic monitoring in natural distribution extremes (ALNUSGENMON)". Research supervisor Prof. Dr Filippos A. Aravanopoulos, post-doc Dr Rita Verbylaitė. 2020–2022 m.
5. "Evaluation of phytocomponents on the functional and physical properties of silicone caoutchouc composite". Research supervisor Prof. Dr Pranas Viškelis, post-doc Dr Aistė Balčiūnaitienė (Lisauskaitė). 2020–2022.
6. "The influence of agrotechnological measures on fibre hemp (*Cannabis sativa* L.) morphological parts phytochemical composition". Research supervisor Dr Vita Tilvikienė, post-doc Dr Karolina Barčauskaitė. 2020–2022.

Projects of the national research programme "Sustainability of agro-, forest and water ecosystems"

1. "Management of greenhouse gas emissions by changing nitrogen flows in the agro-system". Project leader Dr Vita Tilvikienė. 2020–2021.
2. "Sustainable forage crops productivity under climate extremes: resilience, nutritional quality and implications for future management". Project leaders Prof. Dr habil. Romualdas Juknys (VDU), Dr Vaclovas Stukonis (LAMMC). 2020–2021.
3. "Dynamic changes and restoration of soil properties, fungal and insect communities following clearcutting and biomass utilization in pine ecosystems". Project leader Assoc. Prof. Dr Artūras Gedminas. 2020–2021.

Development of scientific competence of scientists, other researchers, and students through practical scientific activities funded by the European Union funds

Sub-activity "Development of students' competences through participation in scientific summer practice"

1. "Assessing the biopotential of hemp in the context of achieving the Green Deal objectives". Supervisor Dr Vita Tilvikienė, doctoral student Gabija Žalpytė. 2 July–31 August 2021.
2. "Investigations of chemical composition and antimicrobial activity of *Artemisia dubia* Wall". Supervisor Dr Romas Mažeika, doctoral student Rugilė Telinskytė. 2 July 2021–31 August 2021.
3. "Application of fluorescent dyes for seed protein carbonylation analysis". Supervisor Dr Danas Baniulis, doctoral student Edgaras Tamelis.2 June–31 August 2021.

Sub-activity "Development of students' abilities in scientific (art) research during semesters"

1. "Assessment of the biopolymer chitosan impact on the Scots pine (*Pinus sylvestris*) early development and formation of antipathogenic resistance". Supervisor Dr Vaida Sirgedaitė-Šėžienė, doctoral student Milana Augustauskaitė. 1 September 2021–31 March 2022.
2. "Plant and endophytic bacteria interaction analysis using *in vitro* model system". Supervisor Dr Danas Baniulis, doctoral student Edgaras Tamelis. 1 September 2021–31 March 2022.
3. "The impact of *Fraxinus excelsior* and *Populus tremula in vitro* cultures and symbiotic bacteria interaction on the development of antipathogenic resistance in these trees". Supervisor Dr Vaida Sirgedaitė-Šėžienė, doctoral student Greta Striganavičiūtė. 3 November 2020–30 April 2021.
4. "Characterisation of brown rot pathogens genetic diversity using microsatellite markers". Supervisor Prof. Dr habil. Vidmantas Stanys, doctoral student Raminta Žukauskaitė. 3 November 2020–30 April 2021.
5. "In-season prediction of cereals nitrogen status and yield with an unmanned aerial vehicle (UAV)". Supervisor Dr Renaldas Žydelis, doctoral student Ardas Kavaliauskas. 3 November 2020–30 April 2021.

Applied research funded by the Ministry of Agriculture of the Republic of Lithuania

Agricultural, food, and fisheries research and development projects

1. "Development of integrated pest management guidelines for harmful organisms control in main greenhouse crops". Project leader Dr Neringa Rasiukevičiūtė. 2021–2023.
2. "Research on the development of a functional model of the agricultural knowledge and innovation system in Lithuania". Project leader Dr Rasa Pakeltienė (VMU), coordinator Dr Roma Semaškienė (LAMMC). 2021–2022.
3. "Evaluation and preparation of fibre hemp products as organic carbon accumulators in long-term products and soil for their application according to IPCC methodology in GHG inventory". Project leader Dr Egidijus Zvicevičius (VMU), Dr Vita Tilvikienė (LAMMC). 2020–2022.
4. "Evaluation of factors limiting the yield of beans and peas and their management with IPM tools". Project leader Dr Roma Semaškienė. 2020–2022.
5. "The state of agricultural crop stands and yield forecast in Lithuania". Project leader Dr Virginijus Feiza. 2020–2022.
6. "Demonstrating the potential for climate change mitigation in nutrient rich organic soils through research-based national values for greenhouse gas (GHG) emissions from lowland peatlands". Project leader Dr Kęstutis Armolaitis. 2020–2022.

7. "Development of cultivation technologies for quinoa (*Chenopodium quinoa*), chickpeas (*Cicer arietinum*) and amaranth (*Amaranthus*)". Project leader Dr Lina Šarūnaitė. 2020–2022.
8. "Evaluation of effectiveness and perspectiveness of different agricultural practices from economic, energy-efficient and environmental viewpoint". Project leader Dr Dalia Feizienė. 2020–2022.
9. "Glyphosate and AMPA residues and their degradation time in soil and grain". Project leader Dr Gražina Kadžienė. 2019–2021.
10. "Complex investigation and economic-environment evaluation of no tillage (No-till) technology". Project leader Dr Virginijus Feiza. 2019–2021.
11. "Long-term monitoring of soil agrochemical properties". Project leader Prof. Dr habil. Gediminas Staugaitis. 2016–2021.

EIP activity group projects (Programme for the Lithuanian rural development 2014–2020)

1. "Independent application of good agricultural practice on the farm – a virtual assistant to farmers". Project leader Daiva Gurauskienė (LAAS), coordinator Dr Roma Semaškienė (LAMMC). 2020–2023.

Support for Lithuanian beekeeping sector

1. "Comparison of protein composition of mixed aphid and nectar honeydew honey with monofloral clover nectar honey". Supervisor Dr Violeta Čeksterytė. 2021.

Applied research projects funded by the Ministry of environment of the Republic of Lithuania and its subordinate state institutions

1. "Increasing the overall resistance of Lithuania main forest tree species to pathogens by the innovative combination of genetic and physical methods". Project leader Dr Vaida Sirgedaitė-Šėžienė. 2021–2024.
2. "Determination of the influence of growth of young pine and spruce stands at different densities on the productivity and sustainability of stands". Project leader Dr Benas Šilinskas. 2021–2022.
3. "Evaluation of the effectiveness of different bacterial preparations in promoting the development of systemic antipathogenic resistance in Lithuanian coniferous tree species". Project leader Dr Vaida Sirgedaitė-Šėžienė. 2021–2023.
4. "Butt rot impact assessment on sustainability and productivity of Norway spruce stands". Project leader Dr Povilas Žemaitis. 2020–2022.
5. "Evaluation of soil organic carbon sustainability in forest ecosystems". Project leader Dr Vidas Stakėnas. 2020–2023.
6. "The influence of initial stand density and early selective thinning on the spruce tree stems quality". Project leader Dr Marius Aleinikovas. 2020–2022.
7. "Study of possibility to use aspen symbiotic bacteria for biological control of tree-damaging pathogenic fungi". Project leader Dr Jonas Žiauka. 2020–2022.
8. "The first stage of Scots pine intensive breeding (breeding cycle III), based on crossings and progeny testing – selection of genotypes in the field trials, grafting, cultivation of clones, preparation of project for crossings and crossing methodology". Project leader Dr Virgilijus Baliuckas. 2020–2021.
9. "Conservation measures for pedunculate oak, sessile oak and Wych elm gene pool". Project leader Dr Virgilijus Baliuckas. 2020–2023.
10. "Preparation of aspen seed plantation project by identifying the sex of aspen plus trees and establishing the most optimal scheme for crossbreeding". Project leader Dr Rita Verbylaitė. 2020–2022.
11. "Identification of black alder and grey alder F1 generation hybrids and preparation of forest propagating material for field trials". Project leader Dr Virgilijus Baliuckas. 2020–2022.
12. "Development of a unified methodology for drawing up fertilisation plans". Project leaders: Prof. Dr habil. Gediminas Staugaitis, Dr Aistė Masevičienė. 2020–2021.
13. "Preparation facility of the brown hare (*Lepus europaeus*) recovery programme". Project leader Dr Olgirda Belova. 2020–2021.
14. "Level II intensive forest condition monitoring and level I forest soil survey in European network of forest condition monitoring". Project leader Dr Vidas Stakėnas. Customer – State Forest Service. 2020–2021.
15. "Preparation of genetic monitoring methodology for Scots pine, Norway spruce, pedunculate oak and silver birch". Project leader Dr Virgilijus Baliuckas. 2019–2021.

Projects of RTO Lithuania

1. "Plant nutrients recovery using secondary raw materials" (NUTREC). Project coordinators: Dr Karolina Barčauskaitė (LAMMC), Dr Marius Urbonavičius (LEI) Dr Ilja Ignatjev (FTMC). 8 February – 8 December, 2021.
2. "New methods of extracting valuable substances from algae grown in complex multitrophic aquaculture" (ExtraIMTA). Project coordinators: Dr Arūnas Stirkė (FTMC), Dr Eugenija Bakšienė (LAMMC), Dr Liutauras Marcinauskas (LEI). 8 February – 8 December, 2021.
3. "Development of biodegradable biofuel cells" (BioDegra). Project coordinators: Prof. Dr habil. Arūnas Ramanavičius (FTMC), Dr Monika Vilkienė (LAMMC), Dr Nerijus Striūgas (LEI). 8 February – 8 December, 2021.

Students' scientific practice

1. Pathogenicity and biological control of microscopic fungi from different plant hosts. Supervisor Dr Neringa Rasiukevičiūtė, doctoral student Aira Rudinskaitė (KTU).
2. Species composition and biocontrol of horticultural pathogens from soil and weeds. Supervisor Dr Neringa Rasiukevičiūtė, doctoral student Greta Laurinaitytė (KTU).
3. Strawberry anthracnose – harmfulness and biocontrol. Supervisor Dr Neringa Rasiukevičiūtė, doctoral student Laura Vaidelytė (KTU).
4. Efficacy of apple disease and pest control system, pathogenicity of apple rot agents and their spread during fruit storage. Supervisor Dr Alma Valiuškaitė, doctoral student Greta Rimkutė (VMU).
5. Search, identification, and *in vitro* biocontrol of carrot pathogens in storage. Supervisor Dr Neringa Rasiukevičiūtė, doctoral student Jogilė Grišiūtė (VMU).
6. Influence of abiotic and biotic factors on the viability and longevity of vegetable seeds. Supervisor Dr Rasa Karklelienė, doctoral student Edgaras Danielius Kodis (KTU).
7. Application of mineral and organic fertilisers for fertilisation of light textured soil. Supervisor Dr Eugenija Bakšienė, doctoral student Linas Marcinkevičius (VMU).
8. Gaining theoretical and practical knowledge on methods and procedures for soil structure (aggregation, water permeability, water retention) determination. Supervisor Dr Virginijus Feiza, doctoral student Anicetas Lenkis (VMU).
9. Effects of wood biofuel ash on the maize micro- and macro-elements composition in acid soil. Supervisor Dr Kristina Bunevičienė, doctoral student Ieva Bagamulskytė (KTU).

13.3. MAJOR SCIENTIFIC PUBLICATIONS

Articles in the journals indexed in *Clarivate Analytics Web of Science* database (impact factors for 2020/2021)

1. Tedersoo L., Mikryukov V., Anslan S., Bahram M., Khalid A. N., Corrales A., Agan A., Aída-M. Vasco-Palacios A.-M., Saitta A., Antonelli A., Rinaldi A. C., Verbeken A., Sulistyo B. P., Tamgnoue B., Furneaux B., Ritter C. D., Nyamukondiwa C., Sharp C., Marín C., Dai D. Q., Gohar D., Sharmah D., Biersma E. M., Cameron E. K., De Crop E., Otsing E., Davydov E. A., Albornoz F. E., Brearley F. Q., Buegger F., Gates G., Zahn G., Bonito G., Hiiesalu I., Hiiesalu I., Zettur I., Barrio I. C., Pärn J., Heilmann-Clausen J., **Ankuda J.**, Kupagme J. Y., Sarapuu J., Maciá-Vicente J. G., Fovo J. D., Geml J., Alatalo J. M., Alvarez-Manjarrez J., Monkai J., Põldmaa K., Runnel K., Adamson K., Bråthen K. A., Pritsch K., Tchan K. I., **Armolaitis K.**, (...), Abarenkov K. 2021. The Global Soil Mycobiome consortium dataset for boosting fungal diversity research. Fungal Diversity, 21 October 2021. **IF – 20,372**
2. Rodrigues L., Hardy B., Huyghebeart B., Fohrafellner J., Fornara D., Barančíková G., Bárcena T. G., De Boever M., Di Bene C., **Feizienė D.**, Käetterer T., Laszlo P., O'Sullivan L., Seitz D., Leifeld J. 2021. Achievable agricultural soil carbon sequestration across Europe from country-specific estimates. Global Change Biology, 27 (24): 6363–6380. **IF – 10,863**
3. **Žemaitis P.**, Linkevičius E., **Aleinikovas M.**, Tuomasjukka D. 2021. Sustainability impact assessment of glue laminated timber and concrete-based building materials production chains – A Lithuanian case study. Journal of Cleaner Production, 321: 25 October 2021, 129005. **IF – 9,297**
4. Centorcelli J. C., **Drapanauskaite D.**, Handler R. M., Baltrusaitis J. 2021. Solar steam generation integration into the ammonium bicarbonate recovery from liquid biomass digestate: process modeling and life cycle assessment. ACS Sustainable Chemistry & Engineering, 9 (45): 15278–15286. **IF – 8,198**

5. **Drapanauskaite D.**, Handler R. M., Fox N., Baltrusaitis J. 2021. Transformation of liquid digestate from the solid-separated biogas digestion reactor effluent into a solid NH_4HCO_3 fertilizer: sustainable process engineering and life cycle assessment. ACS Sustainable Chemistry & Engineering, 9 (1): 580–588. **IF – 8,198**
6. **Žydelis R.**, Weihermüller L., Herbstb M. 2021. Future climate change will accelerate maize phenological development and increase yield in the Nemoral climate. Science of the Total Environment, 784: 147175. **IF – 7,963**
7. Byčenkienė S., Pashneva D., Uogintė I., Pauraitė J., Minderytė A., Davulienė L., Plauškaitė K., Skapas M., Dudoitis V., Touqeer G., Andriejauskiene J., **Araminienė V.**, Dzenajavičienė E. F., Sicard P., **Gudynaitė-Franckevičienė V.**, **Varnagirytė-Kabašinskienė I.**, Pedišius N., Lemanas E., Vonžodas T. 2021. Evaluation of the anthropogenic black carbon emissions and deposition on Norway spruce and silver birch foliage in the Baltic region. Environmental Research, 112218. **IF – 6,498**
8. **Braziene Z.**, **Paltanavicius V.**, **Avizienytė D.** 2021. The influence of fulvic acid on spring cereals and sugar beets seed germination and plant productivity. Environmental Research, 195: article 110824. **IF – 6,498**
9. Raudonė L., Liaudanskas M., Vilkickytė G., **Kviklys D.**, Žvikas V., **Viškelis J.**, **Viškelis P.** 2021. Phenolic profiles, antioxidant activity and phenotypic characterization of *Lonicera caerulea* L. berries, cultivated in Lithuania. Antioxidants, 10 (1): 115. **IF – 6,312**
10. Groom Q., Pernat N., Adriaens T., de Groot M., Jelaska S. D., **Marčiulynienė D.**, Martinou A. F., Skuhrovec J., Tricarico E., Wit E. C., Roy H. E. 2021. Species interactions: next-level citizen science. Ecography, 44 (12): 1781–1789. **IF – 5,992**
11. Gudoityte E., Arandarcikaite O., **Mazeikiene I.**, **Bendokas V.**, Liobikas J. 2021. Ursolic and oleanolic acids: plant metabolites with neuroprotective potential. International Journal of Molecular Sciences, 22 (9): 4599. **IF – 5,923**
12. **Visockis M.**, **Bobinaitė R.**, Ruzgys P., Barakauskas J., Markevičius V., **Viškelis P.**, Šatkauskas S. 2021. Assessment of plant tissue disintegration degree and its related implications in the pulsed electric field (PEF)-assisted aqueous extraction of betalains from the fresh red beetroot. Innovative Food Science & Emerging Technologies, 73. **IF – 5,916**
13. **Drapanauskaite D.**, **Buneviciene K.**, Silva M., **Slepetiene A.**, Baltrusaitis J. 2021. Phosphate removal from simulated wastewater using industrial calcium-containing solid waste. Journal of Environmental Chemical Engineering, 9 (6): 106575. **IF – 5,909**
14. Mullett M. S., Drenkhan R., Adamson K., Boroń P., Lenart-Boroń A., Barnes I., Tomšovský M., Jánošíková Z., Adamčíková K., Ondrušková E., Queloz V., Piškur B., Musolin D. L., Davydenko K., Georgieva M., Schmitz S., **Kačergius A.**, Ghelardini L., Kranjec Orlović J., Müller M., Oskay F., Hauptman T., Halász Á., Markovskaja S., Solheim H., Vuorinen M., Heinzelmann R., Hamelin R. C., Konečný A. 2021. Worldwide genetic structure elucidates the Eurasian origin and invasion pathways of *Dothistroma septosporum*, causal agent of Dothistroma needle blight. Journal of Fungi, 7 (2): 111. **IF – 5,816**
15. **Rasiukevičiūtė N.**, **Brazaitytė A.**, **Vaštakaitė-Kairienė V.**, **Kupčinskienė A.**, **Duchovskis P.**, **Samuolienė G.**, **Valiuškaitė A.** 2021. The effect of monochromatic LED light wavelength and photoperiod on *Botrytis cinerea*. Journal of Fungi, 7 (11): 970. **IF – 5,816**
16. Rodríguez-Pires S., Espeso E. A., **Rasiukevičiūtė N.**, Melgarejo P., De Cal A. 2021. Light-photoreceptors and proteins related to *Monilinia laxa* photoresponse. Journal of Fungi, 7 (1): 32. **IF – 5,816**
17. **Samuolienė G.**, **Viršilė A.**, **Miliauskienė J.**, **Haimi P. J.**, **Laužikė K.**, **Brazaitytė A.**, **Duchovskis P.** 2021. The physiological response of lettuce to red and blue light dynamics over different photoperiods. Frontiers in Plant Science, 11: 2294. **IF – 5,753**
18. Azeem I., Adeel M., Ahmad M. A., Shakoor N., Jiangcuo G. D., Azeem K., Ishfaq M., Shakoor A., **Ayaz M.**, Xu M., Rui Y. 2021. Uptake and accumulation of nano/microplastics in plants: A critical review. Nanomaterials, 11 (11): 2935. **IF – 5,076**
19. **Jurgutis L.**, **Šlepetienė A.**, **Amalevičiūtė-Volungė K.**, **Volungevičius J.**, **Šlepetys J.** 2021. The effect of digestate fertilisation on grass biogas yield and soil properties in field-biomass-biogas-field renewable energy production approach in Lithuania. Biomass and Bioenergy, 153: October 2021. **IF – 5,061**
20. Alemu A., **Brazauskas G.**, Gaikpa D. S., Henriksson T., Islamov B., Jørgensen L. N., Koppel M., Koppel R., **Liatukas Ž.**, Jan T. Svensson J. T., Chawade A. 2021. Genome-wide association analysis and genomic prediction for adult-plant resistance to Septoria tritici blotch and powdery mildew in winter wheat. Frontiers in Genetics, 12 May, 2021. **IF – 4,599**
21. Marzec-Schmidt K., Börjesson T., **Supronienė S.**, Jędryczka M., **Janavičienė S.**, Góral T., Karlsson I., **Kochiieru Y.**, Ochodzki P., **Mankevičienė A.**, Piikki K. 2021. Modelling the effects of weather conditions on cereal grain contamination with deoxynivalenol in the Baltic Sea region. Toxins, 13 (11): 737. **IF – 4,546**
22. Butkeviciute A., **Viskelis J.**, Liaudanskas M., **Viskelis P.**, **Bobinas C.**, Janulis V. 2021. Variation of triterpenes in apples stored in a controlled atmosphere. Molecules, 26 (12): 3639. **IF – 4,411**
23. **Dėnė L.**, **Valiuškaitė A.** 2021. Sensitivity of *Botrytis cinerea* isolates complex to plant extracts. Molecules, 26 (15): 4595. **IF – 4,411**
24. Raudone L., **Puzerytė V.**, Vilkickyte G., Niekyte A., **Lanauskas J.**, **Viskelis J.**, **Viskelis P.** 2021. Sea buckthorn leaf powders: the impact of cultivar and drying mode on antioxidant, phytochemical, and chromatic profile of valuable resource. Molecules, 26 (16): 4765. **IF – 4,411**

25. **Gorash A.**, **Armonienė R.**, Kazan K. 2021. Can effectoromics and loss-of-susceptibility be exploited for improving *Fusarium* head blight resistance in wheat? The Crop Journal, 9 (1): 1–16. **IF – 4,407**
26. **Jaškūnė K.**, **Kemešytė V.**, **Aleliūnas A.**, **Statkevičiūtė G.** 2021. Genome-wide markers forseed yield and disease resistance in perennial ryegrass. The Crop Journal (*in press*). **IF – 4,407**
27. Klavins L., Maaga I., Bertins M., Hykkerud A. L., Karppinen K., **Bobinas Č.**, Salo H. M., Nguyen N., Salminen H., Stankevica K., Klavins M. 2021. Trace element concentration and stable isotope ratio analysis in blueberries and bilberries: A tool for quality and authenticity control. Foods, 10 (3): 567. **IF – 4,350**
28. Tolpeznikaite E., Bartkevics V., Ruzauskas M., Pilkaityte R., **Viskelis P.**, **Urbonaviciene D.**, Zavistanaviciute P., Zokaityte E., Ruibys R., Bartkiene E. 2021. Characterization of macro- and microalgae extracts bioactive compounds and micro- and macroelements transition from algae to extract. Foods, 10 (9): 2226. **IF – 4,350**
29. Zokaityte E., Siriakovaite K., Starkute V., Zavistanaviciute P., Lele V., Mozuriene E., Klupsaite D., **Viskelis P.**, Ruibys R., Guiné Raquel P. F., Bartkiene E. 2021. Characteristics of nutraceutical chewing candy formulations based on fermented milk permeate, psyllium husk, and apple by-products. Foods, 10 (4): 777. **IF – 4,350**
30. Zvikas V., **Urbanaviciute I.**, Bernotiene R., Kulakauskiene D., Morkunaite U., Balion Z., Majiene D., Liaudanskas M., **Viskelis P.**, Jekabsone A., Jakstas V. 2021. Investigation of phenolic composition and anticancer properties of ethanolic extracts of Japanese quince leaves. Foods, 10 (1): 18. **IF – 4,350**
31. **Barcauskaite K.**, **Drapanauskaitė D.**, Silva M., Murzin V., **Doyeni M.**, Urbonavicius M., Williams C., **Supronienė S.**, Baltrusaitis J. 2021. Low concentrations of Cu^2+ in synthetic nutrient containing wastewater inhibit $MgCO_3$-to-struvite transformation. Environmental Science: Water Research & Technology, 7: 521–534. **IF – 4,251**
32. **Barčauskaitė K.**, **Mažeika R.** 2021. Chemical composition and risk assessment of spring barley grown in artificially contaminated soil. Environmental Science and Pollution Research, 28 (17): 21684–21695. **IF – 4,223**
33. Iqbal R., Habib-ur-Rahman M., Raza M. A. S., Waqas M., Ikram R. M., Ahmed M. Z., **Toleikiene M.**, **Ayaz M.**, Mustafa F., Ahmad S., Aslam M. U., Waqas M. M., Khan M. T., Aslam M. M., Haider I. 2021. Assessing the potential of partial root zone drying and mulching for improving the productivity of cotton under arid climate. Environmental Science and Pollution Research, 28 (46): 66223–66241. **IF – 4,223**
34. **Andriūnaitė E.**, **Tamošiūnė I.**, **Aleksandravičiūtė M.**, **Gelvonauskienė D.**, **Vinskienė J.**, **Rugienius R.**, **Baniulis D.** 2021. Stimulation of *Nicotiana tabacum* L. ***in vitro*** shoot growth by endophytic *Bacillus cereus* group bacteria. Microorganisms, 9 (9): 1893. **IF – 4,128**
35. **Marčiulynienė D.**, **Marčiulynas A.**, **Lynikienė J.**, **Vaičiukynė M.**, **Gedminas A.**, Menkis A. 2021. DNA-metabarcoding of belowground fungal communities in bare-root forest nurseries: focus on different tree species. Microorganisms, 9 (1): 150. **IF – 4,128**
36. **Striganavičiūtė G.**, **Žiauka J.**, **Sirgedaitė-Šėžienė V.**, **Vaitiekūnaitė D.** 2021. Impact of plant-associated bacteria on the *in vitro* growth and pathogenic resistance against *Phellinus tremulae* of different aspen (*Populus*) genotypes. Microorganisms, 9 (9): 1901. **IF – 4,128**
37. **Striganavičiūtė G., Žiauka J.**, **Sirgedaitė-Šėžienė V.**, **Vaitiekūnaitė D.** 2021. Priming of resistance-related phenolics: A study of plant-associated bacteria and *Hymenoscyphus fraxineus*. Microorganisms, 9 (12): 2504. **IF – 4,128**
38. **Vaitiekūnaitė D.**, **Kuusienė S.**, Beniušytė E. 2021. Oak (*Quercus robur*) associated endophytic *Paenibacillus* sp. promotes poplar (*Populus* spp.) root growth *in vitro*. Microorganisms, 9 (6): 1151. **IF – 4,128**
39. **Vaitiekūnaitė D.**, Snitka V. 2021. Differentiation of closely related oak-associated gram-negative bacteria by label-free surface enhanced Raman spectroscopy (SERS). Microorganisms, 9 (9): 1969. **IF – 4,128**
40. **Arlauskienė A.**, **Gecaitė V.**, **Toleikienė M.**, **Šarūnaitė L.**, **Kadžiulienė Ž.** 2021. Soil nitrate nitrogen content and grain yields of organically grown cereals as affected by a strip tillage and forage legume intercropping. Plants, 10 (7): 1453. **IF – 3,935**
41. **Brazaitytė A.**, **Miliauskienė J.**, **Vaštakaitė-Kairienė V.**, **Sutulienė R.**, **Laužikė K.**, **Duchovskis P.**, Małek S. 2021. Effect of different ratios of blue and red LED light on Brassicaceae microgreens under a controlled environment. Plants, 10 (4): 801. **IF – 3,935**
42. **Chrapačienė S.**, **Rasiukevičiūtė N.**, **Valiuškaitė A.** 2021. Biocontrol of carrot disease-causing pathogens using essential oils. Plants, 10 (11): 2231. **IF – 3,935**
43. **Doyeni M. O.**, **Stulpinaite U.**, **Baksinskaite A.**, **Suproniene S.**, **Tilvikiene V.** 2021. The effectiveness of digestate use for fertilization in agricultural cropping system. Plants, 10 (8): 1734. **IF – 3,935**
44. **Gudyniene V.**, Juzenas S., **Stukonis V.**, **Norkeviciene E.** 2021. Sowing mixtures of native plant species: are there any differences between hydroseeding and regular seeding? Plants, 10 (11): 2507. **IF – 3,935**
45. **Ispiryan A.**, **Viškelis J.**, **Viškelis P.** 2021. Red raspberry (*Rubus idaeus* L.) seed oil: A review. Plants, 10 (5): 944. **IF – 3,935**
46. **Jurys A.**, **Feizienė D.** 2021. The effect of specific soil microorganisms on soil quality parameters and organic matter content for cereal production. Plants, 10 (10): 2000. **IF – 3,935**
47. **Laužikė K.**, **Uselis N.**, **Samuolienė G.** 2021. The influence of rootstock and high-density planting on apple cv. Auksis fruit quality. Plants, 10 (6): 1253. **IF – 3,935**
48. **Miliauskienė J.**, Karlicek R. F., Kolmos E. 2021. Effect of multispectral pulsed light-emitting diodes on the growth, photosynthetic and antioxidant response of baby leaf lettuce (*Lactuca sativa* L.). Plants, 10 (4): 762. **IF – 3,935**

49. **Morkeliūnė A.**, **Rasiukevičiūtė N.**, **Šernaitė L.**, **Valiuškaitė A.** 2021. The use of essential oils from thyme, sage and peppermint against *Colletotrichum acutatum.* Plants, 10 (1): 114. **IF – 3,935**
50. **Rugienius R.**, **Bendokas V.**, **Siksnianas T.**, **Stanys V.**, **Sasnauskas A.**, Kazanaviciute V. 2021. Characteristics of *Fragaria vesca* yield parameters and anthocyanin accumulation under water deficit stress. Plants, 10 (3): 557. **IF – 3,935**
51. **Sirgedaitė-Šėžienė V.**, **Marčiulynas A.**, **Baliuckas V.** 2021. Effect of extracts from dominant forest floor species of clear-cuts on the regeneration and initial growth of *Pinus sylvestris* L. with respect to climate change. Plants, 10 (5): 916. **IF – 3,935**
52. **Sivojiene D.**, **Kacergius A.**, **Baksiene E.**, **Maseviciene A.**, **Zickiene L.** 2021. The influence of organic fertilizers on the abundance of soil microorganism communities, agrochemical Indicators, and yield in east Lithuanian light soils. Plants, 10 (12): 2648. **IF – 3,935**
53. **Starkus A.**, **Frercks B.**, **Gelvonauskiene D.**, **Mazeikiene I.**, **Rugienius R.**, **Bendokas V.**, **Stanys V.** 2021. Potential markers for selecting self-eliminating apple genotypes. Plants, 10 (8): 1612. **IF – 3,935**
54. **Štreimikytė P.**, **Urbonavičienė D.**, **Balčiūnaitienė A.**, **Viškelis P.**, **Viškelis J.** 2021. Optimization of the multienzyme-assisted extraction procedure of bioactive compounds extracts from common buckwheat (*Fagopyrum esculentum* M.) and evaluation of obtained extracts. Plants, 10 (12): 2567. **IF – 3,935**
55. **Vaštakaitė-Kairienė V.**, Kelly N., S. Runkle E. 2021. Regulation of the photon spectrum on growth and nutritional attributes of baby-leaf lettuce at harvest and during postharvest storage. Plants, 10 (3): 549. **IF – 3,935**
56. **Sirgedaitė-Šėžienė V.**, Mildažienė V., **Žemaitis P.**, Ivankov A., Koga K., Shiratani M., **Baliuckas V.** 2021. Long-term response of Norway spruce to seed treatment with cold plasma: dependence of the effects on the genotype. Plasma Processes and Polymers, 18 (1): 2000159. **IF – 3,872**
57. **Sutulienė R.**, Ragelienė L., **Duchovskis P.**, **Miliauskienė J.** 2021. The effects of nano-copper, -molybdenum, -boron, and -silica on pea (*Pisum sativum* L.) growth, antioxidant properties, and mineral uptake. Journal of Soil Science and Plant Nutrition (*in press*). **IF – 3,872**
58. **Drapanauskaite D.**, **Buneviciene K.**, **Repsiene R.**, **Mazeika R.**, Navea J., Baltrusaitis J. 2021. Physico-chemical characterization of pelletized lime kiln dust as potential liming material for acidic soils. Waste and Biomass Valorization, 12: 1267–1280. **IF – 3,703**
59. **Mažeika R.**, **Arbačiauskas J.**, **Masevičienė A.**, **Narutytė I.**, **Šumskis D.**, **Žičkienė L.**, **Rainys K.**, **Drapanauskaite D.**, **Staugaitis G.**, Baltrusaitis J. 2021. Nutrient dynamics and plant response in soil to organic chicken manure-based fertilizers. Waste and Biomass Valorization, 12: 371–382. **IF – 3,703**
60. Clarke N., Kiær L. P., Janne Kjønaas O., Bárcena T. G., Vesterdal L., Stupak I., Finér L., Jacobson S., **Armolaitis K.**, Lazdina D., Stefánsdóttir H. M., Sigurdssonghi B. D. 2021. Effects of intensive biomass harvesting on forest soils in the Nordic countries and the UK: A meta-analysis. Forest Ecology and Management, 482: 118877. **IF – 3,558**
61. **Buneviciene K.**, **Drapanauskaite D.**, **Mazeika R.**, **Tilvikiene V.**, Baltrusaitis J. 2021. Granulated biofuel ash as a sustainable source of plant nutrients. Waste Management and Research, 39 (6): 806–817. **IF – 3,549**
62. **Buneviciene K.**, **Drapanauskaite D.**, **Mazeika R.**, Baltrusaitis J. 2021. A mixture of green waste compost and biomass combustion ash for recycled nutrient delivery to soil. Agronomy, 11 (4): 641. **IF – 3,417**
63. **Doyeni M. O.**, **Baksinskaite A.**, **Suproniene S.**, **Tilvikiene V.** 2021. Effect of animal waste based digestate fertilization on soil microbial activities, greenhouse gas emissions and spring wheat productivity in loam and sandy loam soil. Agronomy, 11 (7): 1281. **IF – 3,417**
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