DESCRIPTION OF THE DOCTORAL STUDY
SUBJECT OF AGRONOMY SCIENCES FIELD

Administrator of doctoral study program: Vytautas Magnus University Agricultural Academy and Lithuanian Research Centre for Agriculture and Forestry
The coordinator of the study subject: Department of Plant Biology and Food Sciences
Course code: AGR8015
Name in English: Storage and processing of plant raw materials
Number of ECTS credits: 7 (187 h, of which for contact work 46 h, for shelf-study 141 h)

Course workload structure and hours:

Type of contact work	***Hours***	***Self-study***		***Hours***
Lectures	42	Control works		-
Practical	-	Practical works		-
Consultations	2	Individual assignment		20
Examination	2	Preparation of the report		21
		Preparation for examination		100

Subject belongs to:

Study Cycle	***Study program***	***Subject type***
Third	Agronomy	Optional

The aim of the course: to provide the latest knowledge on the storage and processing of plant raw material, to develop the skills in integrating interdisciplinary knowledge based on the results of the most advanced fundamental and applied research, to offer, analyse, systemize and critically evaluate new and complex ideas in the search of original scientific decisions that are of public interest and strategic significance in the field of storage, primary preparation and processing into higher value-added components and products of plant raw material.

Prerequisites for entering the course:

Links between the study programme outcomes, course outcomes, study methods and criteria and methods for learning achievement evaluation:

Type of study programme outcomes	***Course outcomes***	***Study methods***	***Criteria and methods for learning achievement evaluation***
Knowledge, its application	Will have the latest systematic research knowledge in solving the problems of improving the storage and processing of plant raw material	*Lecture, given in a problematic, visualized teaching method, case study, discussion*	Knowledge of the qualitative criteria for storing and processing plant raw material, ability to participate in the discussion and to answer the questions
			Ability to assess the influence of biotic and abiotic factors on the quality of stored and processed plant production; to rationally solve the problematic situation;

			interview, managed and assessed by the lecturer and/or practitioner
			Ability to plan and execute applied research or projects related to solving the problems of storing and processing the plant raw material (interview, managed and assessed by the lecturer and/or practitioner)
Skills for research implementation	Will propose, analyse, systematize and critically evaluate modern and complex ideas in the search of original scientific solutions for storing and processing plant raw material	*Individual assignment, case study, brainstorming*	Knowledge of qualitative criteria for storing and processing the plant raw material, presentation of the report, ability to participate in the discussion and answer the questions
	Will plan and carry out scientific large-scale research or projects related to the relevance of solving the problems of processing and storing the crop production	*Report*	Ability to plan and execute applied research or projects related to solving the problems of storing and processing the plant raw material
Special skills	Will create original tools for scientific research	*Report*	Knowledge about the qualitative criteria for storing and processing the plant raw material, timely problems (presentation of the report)
	Will independently implement scientific research	*Individual assignment, case study*	Ability to plan and execute applied research or projects related to solving the problems of storing and processing the plant raw material (presentation of the report, ability to participate in the discussion and answer the questions)
Social skills	Will communicate with colleagues, scientific community and society	*Individual assignment, brainstorming*	Knowledge about the qualitative criteria for storing and processing the plant raw material, timely problems (interview, managed and assessed by the lecturer and/or practitioner)
	Will transfer the novelties and prospects for development, technical, social and cultural progress in its field of activity	*Report*	

	Will develop creative activities and culture, will promote the progress that is favourable to the society	*Individual assignment, case study*	Ability to plan and execute applied research or projects related to solving the problems of storing and processing the plant raw material (presentation of the report)
Personal skills	Will design a further learning perspective for himself and the team of experts. Will take responsibility to critically evaluate strategic decisions in the field of his activity; will quickly respond to dynamic changes in the social, economic, technological environment, reveal and develop personal creative intellectual skills	*Report*	Knowledge about the qualitative criteria for storing and processing the plant raw material, timely problems (presentation of the report)
			Ability to plan and execute applied research or projects related to solving the problems of storing and processing the plant raw material (interview, managed and assessed by the lecturer and/or practitioner)

Content of the course:

Lectures:

1. Management of the system for the analysis of risk factors – 9 hours.

1.1. The latest research achievements, perspectives and problems in Lithuania, the EU and the world on the issues of storage and processing of plant raw material (1 hour).

1.2. Risk assessment – scientific approach to the safety of plant raw material and food. Application of an important control point system for the analysis of risk factors (HACCP). The benefits of the quality and safety management systems of plant food raw material in agribusiness (2 hours).

1.3. Advantages and disadvantages of the Hazard Analysis Critical Control Point (HACCP) system for the analysis of risk factors. Stages of the development of a plan for HACCP system for the analysis of risk factors. Risk factors: biological (microbiological, virological, parasitological), chemical, physical factors. Typical control points (SVT) for quality management in the production of plant and other products (3 hours).

1.4. Food safety management systems: FSSC 22000, ISO 22000, BRC, IFS, Global G.A.P and other standards (3 hours).

2. Processing of plant raw materials – 22 hours.

2.1. Requirements for quality of plant raw materials and suitability for processing. Technological processes. Physical and biochemical changes occurring during the processing (2 hours).

2.2. Processing technologies of grains and seeds, their impact on product chemical composition and physical properties (2.0 hours)

2.3. Changes in the chemical composition of fruits, berries, vegetables, spices and medicinal plants during their processing (2 hours).

2.4. Microbiological bioconversion of plant raw materials. The use of enzymes when processing fruits, berries and vegetables. Fermentation technology. Fermentation is used in the production and preservation of food products. Natural enzymes and industrial enzyme preparations (2 hours).

2.5. Methods for fruits and vegetables processing. Biochemical preservation. Processing methods that increase the dry matter content in the product. Drying: general characteristic of the process; Heat and mass exchange; Equilibrium humidity; Various drying methods. Quick freezing: the effect of freezing speed and temperature on product quality; Physical-chemical processes that occur during the freezing; Defrostation (6 hours).

2.6. Non-thermal technologies for food processing (2 hours).

2.7. Food additives – dyes. Chemical structure, properties and stability of plants raw materials pigments (carotenoids, anthocyanins, flavonoids, etc.) (2 hours).

2.8. Food additives – preservatives, antioxidants. Their significance and utilization in the processing of fruits, berries and vegetables. Storage of the canned fruits, berries and vegetables. Processes, happening during the storage in the canned products. Causes of deterioration and the methods for preventing it (2 hours).

2.9. Processing of plant-based raw materials using innovative and/or alternative technologies (such as pulsed electric field processing (PEF), lyophilization, supercritical carbon dioxide extraction technology, etc.). Valorization of by-products from fruit, berries, and vegetable processing to create high value-added products (2 hours).

3. Storage of plant raw materials – 11 hours.

3.1. The effect of abiotic and biotic factors on the storing the plant raw material (1.5 hour);

3.2. Scientific principles of storage, the essence of biogenesis and the methods for its implementation (1.5 hours);

3.3. Theory and practice of storing the grain. Analysis of grain biological processes. Processes for moisture migration. Microbiological processes of grain mass in their warehouses. Mycotoxins. Grain pests. Progressive methods and techniques for drying. Application of the principles of anabiosis for storing grains. Principles and methods for chemical preservation of grain. Types of grain storage losses and the reasons for their formation (2 hours).

3.4. Theory of potato, vegetable and fruit storage. The influence of biological factors and agro-products for the preservation of stored production. Processes occurring in plant raw material after the harvest. Control of storage conditions (2 hours);

3.5. Biological aspects of storage. The processes of breathing, maturation, microbiological processes and their effect on the preservation. Calm period. Germination of stored raw material and the possibilities for managing this process with chemical and natural means (2 hours);

3.6. Physical characteristics of potato, vegetable and fruit. Physical processes of the raw material held in containers/crates. Their influence on the preservation of raw material. Changes in chemical composition of stored raw material, products in a modified and controlled atmosphere. The characteristic of stationary modern warehouses – naturally and artificially refrigerated warehouses and controlled atmosphere storage facilities (2 hours).

Preparation of the individual assignment:

Topic: The influence of storage and processing on the quality of plant raw material – 20 hours.

Preparation of the report:

Topic: Projects related to solving the storage and processing of plant raw material by using the EU funding – 21 hour.

Methods and structure of the cumulative assessment of students' achievements

Students' achievements are assessed in a 10-grade scale in the system of cumulative assessment. Assessment is carried out in accordance with the criteria for the assessment of the subject's study results.

Structure of the cumulative grade:

Assessment type	*Weighted score*	*Assessment deadline*

Report	0,2	
Individual assignment	0,3	
Examination	0,5	According to individual plan

Required reading:

1. Adeyeye Samuel A.O., Yildiz Fatih. Fungal mycotoxins in foods: A review. Cogent Food & Agriculture. 2016, (2): doi.org/10.1080/23311932.2016.1213127.
2. Bala, B. K. (Bilash K. (2017). *Drying and storage of ceral grains* (Second edition.). Chichester, England: John Wiley & Sons, Ltd.
3. Barba, F. J. (Ed.). (2020). *Present and future of high pressure processing: a tool for developing innovative, sustainable, safe and healthy foods*. Amsterdam, Netherlands; Elsevier.
4. Barba, F. J., Parniakov, O., & Wiktor, A. (Eds.). (2020). *Pulsed electric fields to obtain healthier and sustainable food for tomorrow*. London, England: Academic Press.
5. Bhattacharya, S. (Ed.). (2015). *Conventional and advanced food processing technologies*. Chichester, England: Wiley Blackwell.
6. Cruz, M. I. (2016). *Fruits, vegetables, and herbs: bioactive foods in health promotion* (R. R. (Ronald R. Watson & V. R. Preedy, Eds.). Amsterdam, [Netherlands: Academic Press.
7. Danilčenko, H. Maisto žaliavų kokybės ir saugos valdymas [elektroninis išteklius]:-mokomoji knyga/ Akademija, 2012. 158 p.
8. Danilčenko, H.; Jarienė, E.; Paulauskienė, A. Augalinių maisto produktų kokybė ir apsauga: vadovėlis. Akademija, 2008. 247 p.16. Jarienė, E. Augalinių žaliavų cheminė sauga [elektroninis išteklius]: mokomoji knyga /Akademija, 2012. 137 p.
9. Ferrante, A., Manganaris, G., Ferrante, A., Manganaris, G., Manuela Pintado, M., & Francini, A. (2020). *Bioactive Compounds Biosynthesis and Metabolism in Fruit and Vegetables*. Frontiers Media SA.
10. Gopala Rao, C. (2015). *Engineering for Storage of Fruits and Vegetables - Cold Storage, Controlled Atmosphere Storage, Modified Atmosphere Storage* (1st ed.). San Diego: Elsevier. https://doi.org/10.1016/C2014-0-03394-1
11. Jarienė E., Danilčenko H., Vaitkevičienė N. 2015 Augalinių žaliavų cheminė sauga. Laboratorinių ir praktinių darbų aprašas Akademija, 26 p.
12. Mortimore, S. E., & Wallace, C. A. (2015). *HACCP: a food industry briefing* (Second edition). Newark: Wiley. https://doi.org/10.1002/9781118427224
13. Pataro, G., & Lyng, J. (Eds.). (2016). *High intensity pulsed light in processing and preservation of foods*. New York, New York: Nova Science Publishers.
14. Thompson, A. K. (2014). *Fruit and Vegetables: Harvesting, Handling and Storage* (Third edition.). Newark: Wiley.
15. Thompson, A. K. Fruit and vegetables: harvesting, handling and storage. 3rd edition. Oxford: Wiley-Blackwell, 2015, 1035 p.
16. Thompson, R. K. P. (2018). *Controlled atmosphere storage of fruit and vegetables* (Third edition.). Oxford: CAB International. https://doi.org/10.1079/9781786393739.0000
17. Varzakas, T., Tsarouhas, P., Varzakas, T., & Tsarouhas, P. (2021). *Advances in Food Processing (Food Preservation, Food Safety, Quality and Manufacturing Processes)*. Basel, Switzerland: MDPI - Multidisciplinary Digital Publishing Institute.
18. Yahia, E. M., & Carrillo López, A. (Eds.). (2019). *Postharvest physiology and biochemistry of fruits and vegetables*. Duxford, England: Woodhead Publishing.

Recommended reading:

1. Bautista-Baños, S., Romanazzi, G., & Jiménez-Aparicio, A. (Eds.). (2016). *Chitosan in the preservation of agricultural commodities*. Cambridge, Massachusetts; Academic Press.

2. Kuddus, M. (Ed.). (2019). *Enzymes in food biotechnology: production, applications, and future prospects*. London, United Kingdom: Academic Press, an imprint of Elsevier.
3. Paliyath, G. (Ed.). (2019). *Postharvest biology and nanotechnology of fruits, vegetables and flowers* (2nd ed.). Hoboken, New Jersey: Wiley Blackwell.
4. Schaschke, Carl. (2010). *Developments in high-pressure food processing*. New York: Nova Science Publishers.
5. Singh, R. L., & Mondal, S. (Eds.). (2019). *Food safety and human health*. London: Academic Press.

Course programme designed by

No.	Name, Surname	Institution	Degree	E-mail address
1.	Živilė Tarasevičienė	VMU AA	Prof. Dr.	zivile.taraseviciene@vdu.lt
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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8016	7	VMU AA	Agronomy	Plant Biology and Food Sciences

Course title in Lithuanian

Daržininkystė

Course title in English

Vegetable Science

Study methods	Volume in ECTS credits
Lectures	4
Consultations	1
Individual work	2

Short course annotation in Lithuanian (up to 500 characters)

Tai pasirenkamas studijų dalykas, skirtas gilinti doktoranto kompetencijas daržininkystės mokslo srityje, įgyti ir kritiškai vertinti naujausių daržininkystės mokslinių tyrimų bei technologijų žinias bei metodologijas. Studijų dalyko turinys pabrėžia daržininkystės dalyko tarpdisciplinišKumą.

Short course annotation in English (up to 500 characters)

This is an optional study subject designated to deepen the competencies of the doctoral student in the field of horticultural science; to acquire the specified knowledge and critically evaluate the latest horticultural technologies and methodologies. The content of the study subject emphasizes the interdisciplinary nature of the horticulture subject.

Relevance of the course

Horticulture (vegetables) is intended for doctoral students conducting research work in this field and others seeking to deepen their competencies in modern horticulture science and technology. Knowledge of the subject will provide a more strategic and methodical understanding of the scientific and applied issues in horticultural technologies and vegetable production.

Course aims

To provide the doctoral student with knowledge about the recent scientific achievements and applied aspects of horticulture in the interdisciplinary context of plant biology, biochemistry, and technology; to develop the competencies of the doctoral student to critically evaluate and model the factors and technologies of the cultivation environment that determine the productivity and quality of vegetables. To help apply the acquired knowledge methodically and purposefully in scientific research work.

Content (topics) and methods

Lectures:

1. Global and local trends in horticultural science

1.1. Horticulture as an interdisciplinary subject. Horticultural production systems and value chains.
1.2. Biodiversity of horticultural production. Quality and safety management and standardization in horticulture.
1.3. Sustainability and resource use efficiency in horticulture. Potential impacts of climate change on vegetable cultivation and product quality.
1.4. Precision and digital horticulture.
1.5. Specialties of horticultural research methodologies.

2. Field vegetable cultivation (botanical characteristics of vegetable plants, cultivation techniques).

2.1. Brassica vegetables: kale, brussels sprouts, turnips, cauliflower and broccoli.

2.2. Root vegetables: beetroot, carrots, celery, celeriac, parsnips, swedes, turnips, radishes, radishes.
2.3. Onion vegetables: onions, leeks, garlic.
2.4. Fruiting vegetables: tomatoes, cucumbers, patisons, arugula, courgettes, pumpkins.
2.5. Leafy vegetables: lettuce, spinach, dill, chicory.
2.6. Perennial vegetables: rhubarb, sorrel, horseradish, asparagus.
3. Controlled environment horticulture: technology for plant performance
3.1. Low and hi-tech level greenhouses, Vertical farming and plant factories.
3.2. Control of environmental factors for improved plant productivity and quality.
3.3. Leafy vegetables and herbs in greenhouses and plant factories.
3.4. Tomato, sweet pepper, and other *Solanaceae* vegetables in controlled environment horticultural systems.
3.5. Cucumber and other vegetables in controlled environment horticultural systems.
3.6. Other and alternative crops for controlled environment production.
Study methods:
Lectures are given using a problem-based, visualized teaching method, combining theoretical knowledge with case analysis and discussions and other active learning methods. If necessary, lectures are delivered remotely using programs for organizing remote meetings (MS Teams, Zoom, etc.).
Subject studies are organized through consultations for a small number of students. Periodic face-to-face or remote consultations are provided using programs for organizing remote meetings (MS Teams, Zoom, etc.). Independent learning based on the target and additional materials specified by the teacher is encouraged. In-depth/holistic individual learning is also encouraged.
Each doctoral student is assigned an individual task that is compatible with his doctoral research area and is intended to extend the acquired subject knowledge.

Structure of cumulative score and value of its constituent parts

A criterion ten-point scale is used for the evaluation of student achievements. The final assessment consists of: individual assignment - 40%, exam - 60%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Arteca, R.N. *Introduction to Horticultural Science*; Second edition.; Cengage Learning: Stamford, CT, 2015; ISBN 9781111312794.
2.	Saqib, M.; Anjum, M.A.; Ali, M.; Ahmad, R.; Sohail, M.; Zakir, I.; Ahmad, S.; Hussain, S. Horticultural Crops as Affected by Climate Change. In *Building Climate Resilience in Agriculture*; Jatoi, W.N., Mubeen, M., Ahmad, A., Cheema, M.A., Lin, Z., Hashmi, M.Z., Eds.; Springer International Publishing: Cham, 2022; pp. 95–109 ISBN 9783030794071.
3.	Aitken, A. *Harvesting the Sun: A Profile of World Horticulture Fruit, Vegetables, Flowers, and Ornamental Garden Plants Supporting Life, Providing Food, Bringing Health and Wealth and Creating a Beautiful Planet*; Scripta Horticulturae; ISHS: Leuven, 2012; ISBN 9789066057043.
4.	Midmore, D.J. Horticultural Production Systems. In *Principles of tropical horticulture*; Midmore, D.J., Ed.; CABI: UK, 2015; pp. 85–125 ISBN 9781780645414.
5.	Preece, J.E.; Read, P.E. *The Biology of Horticulture: An Introductory Textbook*; 2nd ed.; J. Wiley: Hoboken, NJ, 2005; ISBN 9780471465799.
6.	Maldonado, I.L. *Horticulture.*; IntechOpen 2012, 2012; ISBN 9789535102526.
7.	*Plant Factory: Basics, Applications and Advances*; Kozai, T., Niu, G., Masabni, J., Eds.; Academic Press, an imprint of Eslevier: London San Diego, CA Campbridge Oxford, 2022; ISBN 9780323851527.

8.	Stanghellini, C.; Van'T Ooster, B.; Heuvelink, E. *Greenhouse Horticulture: Technology for Optimal Crop Production*; Wageningen Academic Publishers: The Netherlands, 2019; ISBN 9789086863297.
9.	Fruit and Vegetables - European Commission. Prieiga internete: https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/fruit-and-vegetables_en
10.	Nacionaliniai ir Europos sąjungos teisės aktai, reglamentuojantys šviežių daržovių kokybę. Prieiga internete: https://zum.lrv.lt/lt/veiklos-sritys/maisto-pramone-ir-kokybe/maisto-kokybe/svieziu-vaisiu-ir-darzoviu-kokybe-1/teises-aktai-8/
11.	Asaduzzaman, M.; Asao, T. *Vegetables - Importance of Quality Vegetables to Human Health*; 2018; ISBN 9781789235074.
12.	Crop production science in horticulture series; 2nd edition.; CABI: Boston, MA: ✓ Heuvelink, E. Tomatoes; 2018; ISBN 9781786394125. ✓ Wehner, T.C. Cucurbits; 2020; ISBN 9781786392930. ✓ Bosland, P.W., Votava, E.J. Peppers: Vegetable and Spice Capsicums; 2012; ISBN 9781780640204. ✓ and other series publications.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Acquaah, G. *Horticulture: Principles and Practices*; 3rd ed.; Pearson Prentice Hall: Upper Saddle River, N.J, 2005; ISBN 9780131144125.
2.	Adams, C.R.; Early, M.P. *Principles of Horticulture*; 0 ed.; Routledge, 2004; ISBN 9781136372049.
3.	*Vegetable Grafting: Principles and Practices*; Colla, G., Pérez-Alfocea, F., Schwarz, D., Eds.; 1st ed.; CABI: UK, 2017; ISBN 9781780648972.
4.	Baranauskienė, M., Kmitas, A., Kmitienė, L., Dirsė, A., & Svetika, P. (1995). *Daržininkystė: Vadovėlis Lietuvos aukšt. m-kloms*. V: Academia.
5.	*Lactuca: Cultivation and Uses*; Krüger, J., Ed.; Plant science research and practices; Nova Science Publishers: New York, 2020; ISBN 9781536177299.
6.	*Plant Factory: An Indoor Vertical Farming System for Efficient Quality Food Production*; Kozai, T., Niu, G., Takagaki, M., Eds.; Elsevier AP: Amsterdam Boston Heidelberg London New York, 2016; ISBN 9780128018484.
7.	Raviv, M. (2019). *Soilless Culture: Theory and Practice: Theory and Practice* (Second edition.). San Diego, CA, USA: Elsevier Science. https://doi.org/10.1016/C2015-0-01470-8
8.	Marcelis, L., & Heuvelink, E. (Eds.). (2019). Achieving sustainable greenhouse cultivation (1st ed.). Scientific journal articles. Main publishers: Springer (Horticulture Advances, Horticulture Research, Horticulture, Environment, and Biotechnology, Horticultural Plant Journal), Elsevier (Scientia Horticulturae ir kt.,), Wiley (Journal of the Science of Food and Agriculture, Horticultural Reviews), ASHS (HortScience, HortTechnology, The Journal of the American Society for Horticultural Science), MDPI (Horticulturae, Plants) et al.

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Akvilė Viršilė	LRCAF	Dr.	akvile.virsile@lammc.lt
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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8017	7	VMU AA	Agronomy	Plant Biology and Food Sciences

Course title in Lithuanian

Sodininkystė

Course title in English

Horticulture

Study methods	Volume in ECTS credits
Lectures	1.5
Consultations	0.1
Exam	0.1
Individual work	5.3

Short course annotation in Lithuanian (up to 500 characters)

Studentai žinos sodininkystės mokslo ir gamybos būklę bei vystymosi tendencijas ir perspektyvas Lietuvoje ir pasaulyje, norminius aktus, reglamentuojančius uogų ir vaisių auginimo, kokybės ir realizavimo klausimus, aplinkos veiksnius ir klimatines sąlygas, sąlygojančias sodininkystės plėtrą, augalų sistematiką, biologiją, morfologiją, architektoniką, sodo augalų augimo, vystymosi, derėjimo dėsningumus, sodo augalų dauginimo, uogynų ir sodų įveisimo, priežiūros bei derliaus dorojimo ypatumus bei technologijas.

Short course annotation in English (up to 500 characters)

The students will know the status, tendencies and perspectives of the development of horticultural science and fruit production in Lithuania and worldwide, normative acts regulating berry and fruit growing, quality and market issues, environmental factors and climatic conditions, which determine the development of horticulture, plant systematics, biology, morphology, architectonics, regularities of orchard plant growth and development, the peculiarities and technologies of plant propagation orchard management and harvest.

Relevance of the course

Students will be able to analyze the changes in the growth, development, and coherence of orchard plants under the influence of anthropogenic and climatic factors, model technologies based on the latest results of fundamental and applied research, propose sustainable strategic ways of solving issues related to the propagation, planting, management yield and harvesting of orchard plants, be involved in the development of balanced nutrition of population enhancing fruit and berry growing and processing of conventional and innovative products, to assess critically the impact of horticultural development on the environment.

Course aims

To provide knowledge and skills on commercial and amateur horticulture, gathering new knowledge about technologies, solutions, methods and processes; to help in preparation of scientific activities, which requires ability to master new knowledge ensuring development of sustainable commercial and amateur horticulture.

Content (topics) and methods

Lectures: 1. Development and perspectives of horticulture. Trends in horticulture. Species of horticultural plants. 2. Horticultural production. Value and demand of fruits in Lithuania, Europe, world. Fruit consumption rates. 3. Development of horticultural science. Research institutions in Lithuania, research directions. 4. Institutions and regulatory acts regulating horticultural production and scientific activities. 5. Topographical and economic conditions for the development of

horticulture. 6. Environmental and climatic factors limiting horticulture. 7. Agrotechnical and environment protection problems in horticulture. 8. Orchard plant systematics, biology, morphology, architectonics. 9. Regularities of orchard plant growth, development and bearing of garden plants. 10. Specific physiological, anatomical and morphological features of orchard plants. 11. Cultivars, peculiarities, techniques and technologies of the propagation of garden plants. 12. Theoretical and technological solutions of the establishment and management of orchards and berry plantations. 13. Quality assurance of planting material. 14. Fruit and berry plant nutrition maintaining high quality harvest and plant growth and bearing potential. 15. Challenges in the young orchards. 16. Specifics of the management of full bearing orchards. 17. Peculiarities of berry plantation management and harvesting. 18. Fruit physiology, peculiarities of harvest, storage, logistics and market. 19. Specifics of perennial orchard plant research and methodology in horticulture.

Study subject methods: lecture material visualized, problematic lectures focusing on critical plant development factors and scientific issues on specific horticultural plant. During the lectures, PhD students are involved into discussions. Targeted readings and presentations are provided for analysis of normative documents regulating horticultural production and scientific activities. Approximately 10 minutes are given to discuss topic of each lecture. In the absence of a minimum number of PhD students, individual consultations will be provided.

Structure of cumulative score and value of its constituent parts

1. Description of the development and perspectives of horticultural science and commercial growing. production and of horticultural science. 2. Description of environmental factors and climatic conditions, plant systematics, biology, morphology, architectonics, horticultural plant growth, development and bearing peculiarities. 3. Acquisition of knowledge about the propagation, planting, management and harvesting of horticultural plants and their application solving challenges of sustainable horticulture. 4. Acquisition of knowledge about the optimization of fruit plant growth and development; selection and implementation of measures determining optimal fruit tree growth and regular bearing. 5. Adaptation of knowledge about the peculiarities of horticultural plant nutrition and its application solving challenges of mineral nutrition. 6. Understanding and applying regulatory acts on horticultural production and research and their adaptation in the development of horticultural technologies. 7. Ability to communicate orally and in writing. 8. Ability to analyze current situation in horticulture, determine and adopt innovative scientific and technological solutions, which determine development of horticultural science and competitive commercial horticulture.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Acquaah G. 2009. Horticulture principles and practices. Pearson Prentice Hall, 2009 - 760 p.
2.	Adams C. R., Early M.P. 2006. Principles of horticulture. Oxford: Elsevier Butterworth-Heinemann, 2004, Repr. 2006. - 230 p.
3.	Forshey C.G. 1992. Training and Pruning. Apple and Pear Trees.- Michigan, 1992.- 166 p.
4.	John E. Preece, Paul E. Read. 2005. The Biology of Horticulture. John Wiley and Sons, Inc. 514 p.
5.	Kviklys D. (Sudarytojas). 2006. Lietuvos ir Latvijos sodininkystės verslo studija. Lietuvos sodininkystės ir daržininkystės institutas. Babtai, 64 p.
6.	Mokslinės metodikos inovatyviems žemės ir miškų mokslų tyrimams. 2013. (Sudarytojai A. Sasnauskas, V. Tilvikienė, R. Mašalaitė). Lietuvos agrarinių ir miškų mokslų centras, Kaunas, 447 p.
7.	Tromp J., Wertheim A.D., Wertheim S.J. 2005. Fundamentals of temperate zone tree fruit production.- Backhuys Publishers. 400 p.

8.	Uselis N. (sudarytojas). 2014. “Auksio“ veislės desertinių obuolių auginimo technologija (Taikant priemonę „Tausojanti aplinką vaisių ir daržovių auginimo sistema“). LAMMC Sodininkystės ir daržininkystės institutas, Babtai, 158 p.
9.	Uselis N. (sudarytojas). 2005. Intensyvios obelų ir kriaušių auginimo technologijos. Lietuvos sodininkystės ir daržininkystės institutas. Babtai, 2005.- 210 p.
10.	Uselis N. (sudarytojas). 2002. Intensyvios uoginių kultūrų auginimo technologijos. Lietuvos sodininkystės ir daržininkystės institutas. Babtai, 2002.- 190 p.
11.	Venskutonis V. 1999. Sodininkystė, Vilnius, 221 p.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Acta Horticulture. Mineral nutrition of deciduous fruit plants// Editors M. Tagliavini.G.H. Neilsen. P. Millard.- Trento, 1993. - 520 p.
2.	Bergmann W., Farbatlas. Ernarungsstorungen bei kulturpflanzen. -Jena, 1983. - 254 p.
3.	Agrariniai ir miškininkystės mokslai; naujausi tyrimų rezultatai ir inovatyvūs sprendimai. Mokslinės konferencijos pranešimai. Lietuvos agrarinių ir miškų mokslų centras (periodinis).
4.	Brown L.V. 2002. Applied principles of horticultural science. - Butterworth Heinemann, 2002. – 322 p.
5.	Kviklienė N. (sudarytoja). 2011. Obuolių skynimo laikas (metodika). LAMMC SDI. Babtai, 27 p.
6.	Lind K., G. Lafer, K. Schloffer, 2003. G. Innerhofer, H. Meister. Organic fruit growing.- CABI publishing. 2003. 281 p.
7.	Naujausios rekomendacijos žemės ir miškų ūkiui. (Redaktorių kolegija. M. Aleinikovas ir kt.) Lietuvos agrarinių ir miškų mokslų centras, Akademija, Kėdainių r. (periodinis).
8.	Viškelis P. (sudarytojas). 2001. Privalomieji kokybiniai reikalavimai šviežiems vaisiams ir daržovėms.- Babtai, 2001. 186 p.
9.	Tuinyla V., A. Lukoševičius (sudarytojai). 1996. Lietuvos pomologija. T.2. Vilnius, 1996. - 390 p.
10.	The Journal of Horticultural Science & Biotechnology
11.	Horticultural Science, Czech Academy of Agricultural Sciences
12.	Journal of the American Society for Horticultural Science
13.	Scientia Horticulturae. Elsevier
14.	European Journal of Horticultural Science. Verlag Eugen Ulmer.
15.	Acta Horticulturae. ISHS

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Nobertas Uselis	VMU AA	Assoc. Prof. Dr. (HP).	nobertas.uselis@lammc.lt
2.	Vidmantas Stanys	LRCAF	Prof. Habil. Dr.	vidmantas.stanys@lammc.lt

Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8018	7	VMU AA	Agronomy	Plant Biology and Food Sciences

Course title in Lithuanian

Augalų fiziologija

Course title in English

Plant physiology

Study methods	Volume in ECTS credits
Lectures	-
Consultations	2
Seminars	1
Individual work	4

Short course annotation in Lithuanian (up to 500 characters)

Kursas priklauso laisvai pasirenkamiesiems dalykams. Kurso metu nagrinėjami fiziologiniai procesai ir jų sąveika įvairiuose augalo augimo tarpsniuose įvairiomis abiotinių ir biotinių veiksnių sąlygomis, išplečiamos žinios apie šių procesų valdymą, siekiant tvarios produkcijos. Tikslas – įgyti teorines žinias augalų fiziologijos srityje ir jas pritaikyti praktikoje. Studijų būdai: konsultacijos, seminarai, individualus darbas.

Short course annotation in English (up to 500 characters)

The course belongs to optional subjects. During the course, physiological processes, and their interactions in various stages of plant growth under various conditions of abiotic and biotic factors are examined, and knowledge about the management of these processes is expanded in order to achieve sustainable production. The goal is to acquire theoretical knowledge in the field of plant physiology and apply it in practice. Methods of study: consultations, seminars, individual work.

Relevance of the course

After completing the course, students will gain knowledge about plant physiological processes at the cell, plant and population levels. Will be able to evaluate the interaction of plant processes with environmental and technological factors of cultivation. The acquired theoretical knowledge will allow searching for practical solutions in the agricultural science and professional activities, will significantly expand knowledge about the management of processes occurring in plants, to achieve sustainable production.

Course aims

The goal is to analyze acquired theoretical knowledge in the field of plant physiology and apply it in practice: to examine physiological processes and their interaction with environmental, anthropogenic, and technological factors; plan research and systematize and analyze data.

Content (topics) and methods

1. Biochemical and physiological processes of the plant cell.
2. Plant water balance (water potential, transport, transpiration).
3. Photosynthesis (photosystems I and II, cyclic and non-cyclic electron transport, C3 (Calvin) and C4 (Hatch-Slack) photosynthetic carbon reduction cycle, CO_2 assimilation CAM pathway).
4. Plant respiration processes (glycolysis, tricarboxylic acid cycle, electron transport chain).
5. Secondary metabolism of plants.
6. Plant nutrition (essential nutrients, their absorption, identification of deficiency and toxicity).
7. Physiology of plant growth and development (ontogenesis, morphogenesis).
8. Phytohormones (principles of hormonal regulation, functions of phytohormones).

9. Plant stress physiology (abiotic and biotic factors, acclimatization, adaptation). *Methods: literature analysis, consultations, seminars, individual work.*

Structure of cumulative score and value of its constituent parts

Individual work and presentation - 40% of the final grade, exam - 60%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Ameen, S., Akhtar, M. S., & Shin, H.-S. (Eds.). (2022). Chlorophylls. London: IntechOpen.
2.	Atta-ur-Rahman. (2021). Frontiers in Natural Product Chemistry. (Atta-ur-Rahman, Ed.). UAE: Bentham Science Publishers.
3.	Bhatla S.C., Lae M.A. Plant Physiology. Development and Metabolism. Springer, 2018. Campbell, A. M., & Paradise, C. J. (2016). Plant physiology. New York, NY: Momentum Press.
4.	Geelen, D., & Xu, L. (Eds.). (2020). The chemical biology of plant biostimulants. Hoboken, New Jersey; Wiley.
5.	Giuseppe Montanaro & Bartolomeo Dichio. (2012). Advances in Selected Plant Physiology Aspects (G. Montanaro, Ed.). Rijeka, Croatia: IntechOpen.
6.	Goloubinoff, P., Woodson, J. D., Strader, L. C., & Fu, Z. Q. (2022). Important questions and future directions in plant biochemistry. Trends in Biochemical Sciences (Amsterdam. Regular Ed.), 47(10), 811–813. https://doi.org/10.1016/j.tibs.2022.07.003
7.	Hasanuzzaman, M., & Nahar, K. (Eds.). (2022). Plant Stress Physiology: Perspectives in Agriculture. London: IntechOpen.
8.	Nobel, P. S. (2020). Physicochemical and environmental plant physiology (5th ed.). London, England: Elsevier Academic Press.
9.	Pezzani, R., & Vitalini, S. (Eds.). (2023). Biological and Pharmacological Activity of Plant Natural Compounds III. MDPI - Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/books978-3-0365-7060-0
10.	Shabala, S. (Ed.). (2017). Plant stress physiology (Second edition.). Wallingford, Oxfordshire, Englan ; CABI.
11.	Szymańska, R., & Szymańska, R. (2021). Responses of Plants to Environmental Stresses. Basel, Switzerland: MDPI - Multidisciplinary Digital Publishing Institute.
12.	Tainz L., Zeiger E., Møller I.M., Murphy A. (2018). Plant Physiology and development. Oxford University Press.
13.	Wu, Y. (Ed.). (2023). Plant Physiology under Abiotic Stresses. Place of publication not identified: MDPI - Multidisciplinary Digital Publishing Institute.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Chaurasia, P. Kumar., & Bharati, S. Lata. (2022). The Chemistry Inside Spices and Herbs. UAE: Bentham Science Publishers.
2.	Dadlani, M., & Yadava, D. K. (2023). Seed Science and Technology: Biology, Production, Quality (1st Edition 2023). Singapore: Springer Nature. https://doi.org/10.1007/978-981-19-5888-5
3.	Fagaria N.K., Baligar V.C., Clark R.B. (2006). Physiology of crop production. New York etc: Food products press., 2006.
4.	Goyal, M. R., & Chauhan, D. N. (Eds.). (2021). Assessment of medicinal plants for human health: phytochemistry, disease management, and novel applications. Burlington, ON, Canada; Apple Academic Press Inc.
5.	Kaur, Pardeep., Mehta, R. G., & Robin. (2021). Bentham Briefs in Biomedicine and Pharmacotherapy Oxidative Stress and Natural Antioxidants. Singapore: Bentham Science Publishers.

6.	Marriott, B. P., Birt, D. F., Stallings, V. A., & Yates, A. A. (Eds.). (2020). Present knowledge in nutrition. Volume 1, Basic nutrition and metabolism (Eleventh edition). London, United
7.	Kingdom; Academic Press, an imprint of Elsevier. Plant metabolism. Methods and Protocols. Ed. by G. Sririam. Springer, 2014.
8.	Plant Physiology under Abiotic Stresses. (2023). Basel: MDPI - Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/books978-3-0365-7219-2
9.	Rao, V. (Ed.). (2020). Phytochemicals in Human Health. London: IntechOpen.

Course programme designed by

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1.	Viktorija Vaštakaitė-Kairienė	VMU AA	Assoc. Prof. Dr.	viktorija.vastakaite-kairiene@vdu.lt
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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8019	7	VMU AA	Agronomy	Agroecosystems and soil sciences

Course title in Lithuanian

Mikrobiologija

Course title in English

Microbiology

Study methods	Volume in ECTS credits
Lectures	1
Consultations	2
Seminars	-
Individual work	4

Short course annotation in Lithuanian (up to 500 characters)

Dalyko paskirtis – suteikti žinių apie mikroorganizmų grupes ir išaiškinti mikroorganizmų morfologinius ir fiziologinius skirtumus bei reikšmę gamtinėse ir antropogeninėse ekosistemose žemės ūkio ir miškininkystės sektoriuose. Skiriamas dėmesys mikrobiologinių procesų dirvožemyje bei mikroorganizmų maisto žaliavose pažinimui ir vertinimui. Mokoma metodų simbiontiniams ir patogeniniams mikroorganizmams tirti, vertinama mikrobiologinė tarša, supažindinama su profilaktinių priemonių taikymu.

Short course annotation in English (up to 500 characters)

Purpose of course - to provide knowledge about groups of microorganisms, to explain morphological and physiological differences in microorganism phylas, to identify the significance of microorganisms in natural and anthropogenic ecosystems in agricultural and forestry sectors. The experience in evaluation of microbiological processes in soil and microorganisms in food raw materials is amplified, methods for testing symbiotic and pathogenic microorganisms are taught, microbiological contamination is assessed, and application of preservation measures is introduced.

Relevance of the course

Doctoral students will be introduced with biological properties of microorganisms and development characteristics, impact on soil / plant / yield and crop quality. Students will be able to analyze, identify and assess microbiological processes in agriculture and forestry. The skills to plan and conduct fundamental and applied research on microbiology will be strengthen, the knowledge on the evaluation of various factors and methods on control the microorganisms will be developed.

Course aims

To develop students' knowledge and skills for implementing of student competencies to identify microorganisms in practice, to perform scientific research along with applying microbiology methods and evaluating of microbiological processes, to solve microbiological problems reflecting the society need, to plan scientific analyses for validation of innovative decisions for microbiology applied societies.

Content (topics) and methods

Lectures / discussions:

1. Objects of the microbiological research: eukaryotes, prokaryotes, non-cellular microorganisms.
2. Morphological and physiological similarities and differences of microorganisms.
3. Bacterial cell structure and features.
4. Structure and features of microscopic fungi.
5. Structure and features of non-cellular microorganisms: virus, viroid, prion.

6. Main aspects of environmental factors determining the development of microorganisms.
7. Microbial nutrient sources: importance of chemical elements and, particularly, carbon, nitrogen and phosphorus.
8. Metabolism of microorganisms: fermentation and application in biotechnology.
9. Metabolism of microorganisms: respiration and application in biotechnology.
10. Soil microorganisms and role in soil development, organic matter decomposition and stimulation for formation of humic substances.
11. Plant raw material microbiology.
12. Significance of microbial diversity for natural ecosystems.
13. Importance of microbial monitoring and microbial resistance in national and European extent.

Individual activities or practical training:

1. Investigation of physical conditions impact on microorganisms.
2. Investigation of chemical conditions impact on microorganisms.
3. Identification of microorganisms using selective and chromogenic nutrient mediums (substrates).
4. Plant raw material and soil microbiological quality evaluation.
5. Approaches of microbiological sustainability assessment in natural systems.

Structure of cumulative score and value of its constituent parts

Doctoral students are scored on the ten-point cumulative assessment and is based on the described criteria for the assessment of the study results: individual activities or practical training - 50 percent of final evaluation; exam - 50 percent of final evaluation. The exam score is given based on student's ability to perform the analyses of individual questions and to discuss. Final examination score to evaluate students' knowledge and abilities are indicated by the examination committee consisting of two course program lecturers and student's supervisor or consultant.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Strohl W.A., Rouse H., Fisher B.D., editors: Harvey R.A., Champe P.C. Microbiology, Philadelphia: Lippincott Williams & Wilkins, 2001.
2.	Masteikienė R. R. Maisto produktų mikrobiologija, Kaunas: Technologija, 2006.
3.	Dabkevičius Z. Mikrobiologijos ir bakteriologijos pagrindai, Šiauliai: Šiaulių universiteto leidykla, 2008.
4.	Pranaitis P. Mikrobiologijos pagrindai, Akademija, Kauno r.: LŽŪU Leidybos centras, 2009.
5.	Snieškienė V., Stankevičienė A. Augalų grybinių ligų sukėlėjai Vytauto Didžiojo universiteto Kauno Botanikos sode, Vytauto Didžiojo universiteto botanikos sodo raštai, Kaunas: Vytauto Didžiojo universiteto leidykla, 2013 (T. 17, p. 165-176).
6.	Wessner D.R., Dupont Ch., Charles T.C. Microbiology, Hoboken: Wiley, 2013.
7.	Buchovec I. Maisto patogenų inaktyvacija fotoaktyvuotu chlorofilinu: poveikio mechanizmas, optimizavimas ir pritaikymo galimybės, Vilniaus universitetas, Gamtos mokslų fakultetas, 2018.
8.	Dongyou Liu. Molecular food microbiology, Boca Raton, Fla.: CRC Press, Taylor & Francis Group, 2021.
9.	Dar G.H., Bhat R.A., Qadri H., Hakeem K.R. Microbial consortium and biotransformation for pollution decontamination. Elsevier, 2022.
10.	Panwar J.S., Sharma D. Microbial resource technologies for sustainable development. Elsevier, 2022.
11.	Cowan M.K., Smith H. Microbiology: a systems approach ISE. McGraw, USA, 2023.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Glazer A.N. Microbial biotechnology: fundamentals of applied microbiology, New York, N.Y.: Cambridge University Press, 2007.
2.	Gadd G., Sariaslani S. Advances in Applied Microbiology, Elsevier Science & Technology,

	2009.
3.	Philippot L., Ritz K., Pandard P., Hallin S., Martin-Laurent F. Standardisation of methods in soil microbiology: progress and challenges, FEMS microbiology ecology, 2012 (Vol. 82 (1)), p. 1-10).
4.	Mendes R., Garbeva P.V., Raaijmakers J.M. The rhizosphere microbiome: significance of plant beneficial, plant pathogenic, and human pathogenic microorganisms, FEMS microbiology reviews, 2013 (Vol. 37 (5), p. 634-663).
5.	Antwis R.E., Harrison X.A., Michael J. Microbiomes of soil, plants and animals: an integrated approach, Cambridge: Cambridge University Press, 2020.
6.	Thiele-Bruhn S., Schloter M., Wilke B.M. et al. Identification of new microbial functional standards for soil quality assessment, Soil, 2020 (Vol. 6, p. 17-34).
7.	Arzu Çelik Oğuz, Aziz Karakaya. Genetic diversity of barley foliar fungal pathogens, Agronomy, 2021 (Vol. 11(3), 434).
8.	Adeleke, B.S., Fadiji, A.E., Ayilara, M.S., Igiehon, O.N., Nwachukwu, B.C., and Babalola, O.O. Strategies to enhance the use of endophytes as bioinoculants in agriculture. Horticulturae, 2022 (Vol. 8 (6), p.498).
9.	Akram, S., Ahmed, A., He, P., He, P., Liu, Y., Wu, Y., Munir, S., and He, Y. Uniting the Role of Endophytic Fungi against Plant Pathogens and Their Interaction. Journal of Fungi, 2023 (Vol. 9 (1), p.72).
10.	Hashem, A.H., Attia, M.S., Kandil, E.K., Fawzi, M.M., Abdelrahman, A.S., Khader, M.S., Khodaira, M.A., Emam, A.E., Goma, M.A., and Abdelaziz, A. M. Bioactive compounds and biomedical applications of endophytic fungi: a recent review. Microbial Cell Factories, 2023 (Vol. 22 (1), p.107).
11.	Wang, Y.L. and Zhang, H.B. Assembly and Function of Seed Endophytes in Response to Environmental Stress. Journal of Microbiology and Biotechnology, 2023 (Vol. 33 (9), p.1119).
12.	Watts, D., Palombo, E.A., Jaimes Castillo, A., and Zaferanloo, B. Endophytes in Agriculture: Potential to Improve Yields and Tolerances of Agricultural Crops. Microorganisms, 2023 (Vol. 11 (5), p.1276.

Course programme designed by

No.	Name, Surname	Institution	Degree	E-mail address
1.	Jūratė Aleinikovienė	VMU AA	Assoc. Prof. Dr.	jurate.aleinikoviene@vdu.lt
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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8020	7	VMU AA	Agronomy	Agroecosystem and soil sciences

Course title in Lithuanian

Augalų patologija

Course title in English

Plant Pathology

Study methods	Volume in ECTS credits
Lectures	1
Consultations	1
Seminars	1
Individual work	4

Short course annotation in Lithuanian (up to 500 characters)

Studijose analizuojami biotiniai ir abiotiniai augalų ligotumo veiksniai. Nagrinėjamos neinfekcinių ligų priežastys, simptomai, diagnostika ir plitimo kontrolė. Studijuojama virusinių, bakterinių ir grybinių ligų sukėlėjai, jų sistematika, ekologija ir dinamika. Aptariami patogeniniai procesai augaluose, imunitetas ligoms. Analizuojami modernūs augalų ligų identifikavimo, apskaitos, plitimo prognozės ir kontrolės metodai. Susipažįstama su žemės ūkio, sodo ir daržo, miško ir dekoratyvinių augalų ir augalinių produktų ligomis, jų plitimo bei žalingumo kontrole.

Short course annotation in English (up to 500 characters)

The studies analyze biotic and abiotic factors affecting plant disease. The origin, symptoms, diagnosis and control of non-infectious diseases are analyzed. The causing organisms of viral, bacterial and fungal diseases, their systematics, ecology and dynamics are studied. Pathogenic processes in plants, immunity to diseases are discussed. Plant disease identification, accounting, prediction and control methods are analyzed. Get acquainted with diseases of agriculture, horticulture, forest and ornamental plants and plant products, disease incidence, severity, harmfulness and control of their.

Relevance of the course

Upon completion of the course the students will be able to identify the causes and origin of infectious and non-infectious plant diseases; to estimate the environmental effects on the development of diseases, to understand the interaction between pathogen and host plant; to know the principals of plant disease epidemiology. Students will be able to recognize and identify most important agricultural, horticultural, forest and ornamental plant diseases and will be able to select appropriate control measures.

Students will be able to choose adequate methods for fundamental and applied research on plant pathogens, disease epidemiology and control measures; will be able to critically evaluate the research results on plant pathology.

Course aims

Aim of studies course is to acquire new knowledge about infectious and non-infectious plant diseases, their causes, origin, interaction of environment, pathogens and plants, about pathogenic microorganisms; to explore plant disease epidemiology; to gain detailed knowledge of the main agricultural plant diseases, their identification and control.

Content (topics) and methods

Topic 1. Introduction to plant pathology.

Topic 2. Non-infectious plant diseases.

Topic 3. Infectious plant diseases. Topic 4. Plant diseases caused by viruses. Topic5. Plant diseases caused by bacteria. Topic 6. Plant diseases caused by fungi. Topic 7. Plant diseases caused by parasitic higher plants. Topic 8. Parasitism and disease development. Epidemiology of plant diseases. Topic 9. How the pathogens attack plants and plants defend themselves against pathogens. Topic 10. Identification, assessment and forecasting of plant diseases. Topic 11. The diseases of agricultural plants: incidence, severity, harmfulness and control methods. Topic 12. The diseases of plant-derived products: prevention and control. Topic 13. The diseases of horticultural and vegetable plants: incidence, severity, harmfulness and control methods. Topic14. The diseases of forest and ornamental plants: incidence, severity, harmfulness and control methods.

Structure of cumulative score and value of its constituent parts

Individual task -25 Practical training and seminars- 25, Final exam -50 .

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Agrios G.N. Plant Pathology – 5 th ed. – Elsevier Academic Press, 2005, 922 p.(1,2)[X]
2.	Biotic Interactions in Plant-pathogen Associations / edited for the British Society for Plant Pathology by M. J. Jeger, N. J. Spence. – New York, 2001, 353 p. (2)
3.	Lucas J. A. Plant Pathology and Plant Pathogens, 1998, – 274 p. (1,2)
4.	Introduction to Plant Pathology / Strange Richard N. - New York: Wiley, 2003, 464 p. (2)
5.	Robert F. Nyval. Field Crop Diseases –Third edition. – Iowa State University Press/Ames, 1999. – 1021p. (2)
6.	Information ir website of European and Mediterranean Plant Protection Organization https://www.eppo.int/

[X] Note: the books are available in libraries: (1) Vytautas Magnus University, Academy of Agriculture
(2) Lithuanian Research Centre for Agriculture and Forestry

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Bacterial Plant Pathology: Cell and Molecular Aspects / David C. Sigee. – Cambridge, UK, 1993. 325 p. (1,2) [X]
2.	Carlile Bill. Pesticide Selectivity, Health and the Environment. Cambridge University Press, UK, 2006. 310 p. (1,2)
3.	Crop Protection Information. An International Perspective. Edited by K. M. Harris and P.R. Scott. – C.A.B. International, UK, 1989, 321 p. (2)
4.	Efficacy Evaluation of Plant Protection Products. Vol. 2 Fungicides & Bactericides: EPPO Standards. – Paris, France, 2004, 198 p. (1,2)
5.	Guidelines for the Efficacy Evaluation of Plant Protection Products. Vol. 1 Introduction, General & Miscellaneous Guidelines, New & Revised Guidelines: EPPO Standards. –Paris, France, 2004, 111 p. (2)
6.	Matthews G.A. Pesticide: Health, Safety and the Environment.-Blackwell Publishing, 2006. 235p. (1)
7.	Matthews' Plant Virology: 4nd ed. / Roger Hull, – Amsterdam, 2004, 1001 p. (2)
8.	Paul Holliday. A Dictionary of Plant Pathology – Second edition. – Cambrige University press, 1998. 536 p. (2)

9.	Plant-fungal Pathogen Interaction: a Classical and Molecular View / Hermann H. Prell, Peter R. Day, - Berlin, London, 2001, 214 p. (2)
10.	Viral Pathogenesis and Immunity / Neal Nathanson. – New York, 2007, 266 p. (2)

[X] Note: the books are available in libraries: (1) Vytautas Magnus University, Academy of Agriculture
(2) Lithuanian Research Centre for Agriculture and Forestr

Course programme designed by

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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.
Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8021	7	VMU AA	Agronomy	Agroecosystem and soil sciences

Course title in Lithuanian

Mikologija

Course title in English

Mycology

Study methods	Volume in ECTS credits
Lectures	1
Consultations	1
Seminars	1
Individual work	4

Short course annotation in Lithuanian (up to 500 characters)

Studijose analizuojama grybų ir panašių į grybus organizmų vieta gyvajame pasaulyje, jų biologija, paplitimas, poreikiai aplinkai. Studijuojama grybų sandara, mityba, dauginimasis, nomenklatūra, taksonomija ir sistematika, simbiontinių ir patogeninių grybų santykiai su augalu šeimininku. Susipažįstama su svarbiausiais augalų patogeniniais grybais, jų ekologiją, identifikavimo metodais

Short course annotation in English (up to 500 characters)

The studies analyse the place of fungi in the living world, their biology, prevalence, environmental needs. Fungi morphology, nutrition, reproduction, nomenclature, taxonomy and systematics, relationship between symbiotic and pathogenic fungi with the host are studying. The most important plant pathogenic fungi, their ecology, identification methods.

Relevance of the course

After mastering the course, students will know about the development of mycology science and the latest achievements, fungi in living organisms, biology, systematics, metabolizm and ecology of fungi, spread of symbiotic, saprophytic, beneficial, toxic and pathogenic fungi; will be able to formulate research problem, goal and tasks in mycology science, to select research methods in fundamental and applied scientific mycology research, to critically evaluate the obtained research results in mycology; Based on the latest scientific knowledge, will be able to develop original methods of mycological research, studies, innovation, tools and tools for regulating fungal populations in the environment.

Course aims

Aim of the course: to acquire new knowledge about the location of fungi and similar fungi organisms in the living world, their biology, distribution, environmental needs. Essential to deepen knowledge about the structure, nutrition, reproduction, nomenclature, taxonomy and systematics of fungi, to get acquainted with the most important symbiotic, saprophytic, beneficial, toxic and pathogenic fungi, to study the relationship between pathogenic fungi and host, ecology of fungi, identification, cultivation and control measures

Subject content, topics and study methods

Topic 1. History and development of mycology in the world and Lithuania.
Topic 2. Morphology of fungi.
Topic 3. Fungal reproductive organs, methods and processes of reproduction.
Topic 4. Fungi needs for environmental conditions, nutrition and metabolism.
Topic 5. Fungal genetics and variability.
Topic 6. Fungal nomenclature, systematics, taxonomy and classification.
Topic 7. Prevalence of fungi in nature, relationship with other organisms, pathogenesis of plants.
Topic 8. Symbiotic, saprophytic, beneficial, toxic and pathogenic fungi, their cultivation and control

of spread.
Topic 9. Methods of identification of fungi.
Topic 10. Mycotoxins, their formation in plant raw materials and products, prevention, and control.
Topic 11. Planning and carrying out mycological studies.
Subject study methods. Lecture material is visualized using multimedia equipment and smart auditorium board. Students are enrolled in discussions individually or by group of questions. In the absence of a minimum number of doctoral students, lectures are not counted and doctoral students, in consultation with the lecturer, independently study topics and present knowledge during practical and control work. Doctoral students are discussing the most important topics, how much the doctoral student's work is closely related to plant pathology, possible methods of investigation of specific pathogens are discussed, where the latest research methodologies can be found and how to use them best in doctoral student work, advised with which scientists can be consulted in more detail. Doctoral students are consulted according to the agreed schedule and correspondence in electronic space.

Structure of cumulative score and value of its constituent parts

The achievements of doctoral students are evaluated using the ten-point cumulative assessment system and according to the envisaged criteria for assessment of the study outcomes of the subject: individual task, exercise, report - 40%. final evaluation; exam - 60 percent final evaluation. The examination score is determined by the ability of the doctoral student to analyze the questions submitted, to discuss with the examining teachers.
The evaluation of the knowledge and skills of the PhD students during the examination and the final assessment is carried out by a commission consisting of one or two subject teachers and the supervisor or consultant of the doctoral student.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Advances in Food Mycology. Edited by A.D. Hocking, J.I. Pitt, R.A. Samson and U. Thrane. 2006. Springer.
2.	Ainsworth & Bisby's dictionary of the fungi: 9th ed. / by P.M. Kirk [et al.]. - Wallingford. – 2001, 655 p.
3.	Carlile, M.J., Watkinson, S., C. Gooday G., W. The fungi. Amsterdam. 2001. 588 p.
4.	Hermann H. Prell, Peter R. Day. Plant-fungal pathogen interaction: a classical and molecular view, Berlin, London, 2001, 214 p.
5.	Mycotoxins in food. Edited by N. Magan and M. Olsen. 2004. CRC Press. USA.
6.	Mycotoxins in Food, Feed, and Bioweapons. Edited by Mahendra Rai and Ajit Varma. 2010. Springer.
7.	Mycotoxins. Properties, Applications, and Hazards. Edited by Bryan J. Melborn and Jason C. Greene. 2012. NOVA Science Publishers, Inc., New York, USA.
8.	Ramesh Maheshwari. Fungi experimental models in biology, Boca Raton, London, 2005, 204 p.
9.	The Mycotoxin Blue Book. Edited by Duarte Diaz. 2005. Nottingham University Press. England.
10.	COMMISSION REGULATION (EU) 2023/915 of 25 April 2023 on maximum levels for certain contaminants in food and repealing Regulation (EC) No 1881/2006. Official Journal of the European Union L 119/103.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Butt T.M., Jackson C., Magan N. Fungi as biocontrol agents: progress, problems and potential. Cambrige, Mass.: CABI, -2001, 390 p.
2.	Dugan, Frank M. The identification of fungi: an illustrated introduction with keys, glossary, and guide to literature. St. Paul, Minn., 2003, 176 p.
3.	Pitt J.I., Hocking D. Fungi and food spoilage. Gaithersburg, 1999, 539 p.
4.	Webster John. Introduction to fungi. Cambridge, 2011, 841 p.
5.	Watanabe, T. Pictorial atlas of soil and seed fungi: morphologies of cultured fungi and key to

	species. Boca Raton, 2002, 484 p.

Course programme designed by

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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8023	7	VMU AA	Agronomy	Plant Biology and Food Sciences

Course title in Lithuanian

Bitininkystė

Course title in English

Apiculture

Study methods	Volume in ECTS credits
Lectures	3
Consultations	1
Seminars	-
Individual work	3

Short course annotation in Lithuanian (up to 500 characters)

Bitininkystės dalyko studijos skirtos Agronomijos mokslo krypties doktorantams. Studijuodami šį dalyką doktorantai susipažins su bitininkavimu Lietuvoje ir ES keliamais reikalavimais. Bičių šeimos biologija, ligomis ir parazitais, bityno inventoriumi, pagrindiniais bičių ganyklų augalais, bičių priežiūra, apsauga, gydymu ir selekcija. Gebės vertinti bites kaip agrotechninę žemės ūkio šaką. Žinos ir įvertins kompleksinį bitininkavimą, bičių produktų gamybą ir jų pritaikymą.

Short course annotation in English (up to 500 characters)

Studies in beekeeping subjects are aimed at doctoral students in the field of Agronomy. While studying this subject, doctoral students will get acquainted with the requirements of beekeeping in Lithuania and the EU. Bee family biology, diseases and parasites, apiary inventory, main bee pasture, bee care, protection, treatment of diseases and breeding. Will be able to evaluate bees as an agrotechnical branch of agriculture. Will know and appreciate the complex beekeeping, the production of bee products and their application.

Relevance of the course

There is a doctoral program in beekeeping at a single higher education institution. The module includes the mastery of general and specific competences, theoretical and scientific knowledge about beekeeping, the ability to analyse and evaluate research work.

Course aims

To transfer knowledge, payments, skills about beekeeping, to analyse theoretically and practically as a branch of agriculture, agrotechnical tool, biological whole. Expand general and special competences for students. At the following levels of the cognitive sphere: the mastery of theoretical and scientific knowledge of beekeeping, the ability to analyse and evaluate scientific research work.

Content (topics) and methods

1. INTRODUCTION
1.1 Beekeeping in other countries: industrial beekeeping in the US and Canada; Opportunity to bite in cold climates; beekeeping in European countries.
1.2 Bees in Lithuania: History; amateur beekeeping before World War I; beekeeping in interwar Lithuania; the importance of public beekeeping; the direction of today's beekeeping, science, education.
2. BIOLOGY OF BEES AND THEIR FAMILY
2.1 Bee family.
2.2. Bee's external structure
2.3. Bite's internal organs.

2.4. Types of food and its uptake.
2.5. Bee genotype.
2.6. Bee communication, age-based work.
2.7. Bee family members.
2.8. Bee genetics, systematics of domestic bees.
2.9. Bee nest.
3. APIARY AND EQUIPMENT
3.1. History of Beehive.
3.2. Classification of frame hives.
3.3. Beehives classification.
3.4. Beekeeping supplies: for bees, queens, products, protection.
3.5. Artificial honeycombs and their framing.
4. BEE PASTURE
4.1. Influence of weather on bee and blossom nectars.
4.2. Understanding and classification of pastures.
4.3. Available in the spring, summer and fall.
4.4. Evaluation of plant nectars.
4.5. Sticky jellyfish.
4.6. Ways of exploiting and improving bee pastures.
4.7. Available for crop rotation for bees.
4.8. Indicative calculation of pasture.
5. CARE AND BREEDING OF BEES
5.1. About the safe work of the apiary.
5.2. Carriage of bees.
5.3. Bee fly and their significance.
5.4. Spring bee inspection.
5.5. Slots expansion modes: gradual and single.
5.6. Use of magazines (hunts).
5.7. Works in the main honeycomb.
5.8. Means of mood suppression.
5.9. Possible medics: spring, main, autumn.
5.10. Family preparation for the winter: the best time; quantity and quality of food.
5.11. Bee wintering.
5.12. Genetic basics of bee selection: family relationships; sexual inheritance; mating, about diploid transients.
5.13. Selection methods.
5.14. Boning for bees and queens.
5.15. Techniques for breeding queen bees.
5.16. Techniques for marking and changing the nurses
5.17. Works with natural and artificial clusters.
5.18. Different beekeeping methods: Krikščiūnas method, multistorey and duplex beekeeping, beekeeping in various bits, availability of half frames.
5.19. Beekeeping for early ewes.
5.20. About packaging beekeeping possibilities.
6. BEE - AGROTECHNICAL MEASURE
6.1. Methods of pollination of blossoms.
6.2. Types of pollinators (wind, insects, birds).
6.3. The significance of bee families per hectare: garden plants, legumes.
6.4. Determination of bee sufficiency for pollination in red clover.
6.5. Ways to attract bees.

6.6. Bees in greenhouses.
6.7. Bee protection with pesticides.
7. BIRD CRAFT AND DISEASES
7.1. Characteristics of microorganisms.
7.2. Immunity.
7.3. Sanitary rules for bee care.
7.4. Protection of bees and their products.
7.5. Methods of disinfection.
7.6. Major bee pests: filant, bitlesis, varroa mites and others.
7.7. Bee nest pest.
7.8. The main diseases of the brood include rot, blight, fungal diseases and various deaths.
7.9. Adult bee diseases: nozenematosis, acaraphyosis, toxicosis, etc.
7.10. Treatments for bees.
8. COMPLEX BITCHING
8.1. Traditional honey production: family productivity, honey extraction, honey composition, methods of storage and use.
8.2. Wax, its raw material processing techniques, use
8.3. Pollen, its chemical composition, methods of collection and preservation, bread
8.4. Bee milk, its collection, storage and use
8.5. Poison poisoning, extraction and consumption.
8.6. Ways of picking bee pitch and potential for use them.
8.7. The economic importance of collecting bee products

Structure of cumulative score and value of its constituent parts

A ten-point Critical Scale and Cumulative Scoring Scheme are applied. The tasks of independent work of the semester are evaluated by grade, the final assessment is determined during the examinations, the intermediate evaluations are multiplied by the weighted factor and the product is summed up.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Bitininkystės pagrindai/ Algirdas Amšiejus - Aleksandro Stulginskio universitetas, 2014, 172p.
2.	Pradedantiems bitininkams/ Algirdas Skirkevičius, Algirdas Amšiejus, Honas Balžekas, Laima Blažytė-Čereškienė. Vaibra (ISBN: 9789955862567), 2018, 168 p.
3.	Bičių metai/ Algirdas Amšiejus - Alma littera, 2021, 368p.
4.	Bitininkavimas daugiaaukščiuose bedugniuose aviliuose/ Algirdas Amšiejus – Technologija, 2013, 54 p.
5.	Bičių motinėlių auginimas ir atranka/ Algirdas Amšiejus – Technologija, 2012, 60 p.
6.	Akademikas Jonas Kriščiūnas / Sudaryt. P. Vasinauskas – V., 1979, 146 p.
7.	Balžekas J. Bitės ir raudonieji dobilai sėklai. – V., 1985, 128 p.
8.	Bitininkystė. – V., 1970, 447 p.
9.	Bitininko žinynas / sudaryt. J. Balžekas – V., 1987, 380 p.
10.	H. Clement, Y. Le Conte. Le Traite Rustica de l'Apiculture. – Rustica. 2003, – 1 – 528 p.
11.	L. Goodman. Form and Function in the Honey Bee. Ibra. 2003, – 1 – 221 p.
12.	Dadant and Sons. Inc. Mites of the Honey Bee. Printed in the U.S.A., by Book Masters, Inc. Mansfield, Ohio. 2001, – 1 – 280 p.
13.	Lietuvos bitininkas. – V., nuo 1993 – Nr.
14.	Gerlt – Seifert L. Bienenkrankheiten und Schadlige. – Berlin, 1982, – 159 p.
15.	Hodowla pszczol. – Warszawa, 1978, 528 s.
16.	A. Matheson. New perspectives on Varroa. International Bee Research Association, 1994 - 162 p.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.

1.	Straigis J. Bitininkystė. – V., 1994, 208 p.
2.	Алпатов В.В. Породы меденосной пчелы. – М., 1948, 184 с.
3.	Батлер К. Дж. Мир медоносной пчелы. – М., 1980, 232 с.
4.	Малаю А. Итенсификация производства меда. – М., 1979, 176 с.
5.	Медоносная флора основа пчеловодства. – Бухарест, 1977, 249 с.
6.	Пчеловодство – малая энциклопедия /Редкол.: Г.Д. Билаш, А.Н. Бурмистров, В.Г. Гребцова и др. – М., 1991, 510 с.
7.	Скиркявичус А. Феромонная комуникация насекомых. – В., 1986, 291 с.

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Povilas Mulerčikas	VMU AA	Assoc. Prof. Dr.	povilas.mulercikas@vdu.lt
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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8023	7	VDU ŽŪA	Agronomy	Agroecosystems and Soil Sciences

Course title in Lithuanian

Bestuburių zoologija ir entomologija

Course title in English

Invertebrate zoology and entomology

Study methods	Volume in ECTS credits
Lectures	2
Consultations	1
Seminars	1
Individual work	3

Short course annotation in Lithuanian (up to 500 characters)

Bestuburių zoologijos ir entomologijos kursas supažindina su bestuburių gyvūnų įvairove ir sistematika. Studijų metu analizuojami įvairūs vienaląsčiai organizmai, jų išorinė ir vidinė kūno sandara bei ekologija ir įvairovė. Tai pat ir daugialąsčiai bestuburiai gyvūnai, jų anatomija, morfologija ir ekologija. Nagrinėjama įvairių bestuburių grupių charakteristika, apžvelgiant pagrindinius biologinius aspektus: mitybą, elgsenos ypatumus, dauginimosi ir gyvenimo ciklus, pasiskirstymą ir adaptacijas tam tikrai aplinkai. Studijų metu apžvelgiama kiekvienos bestuburių grupės rūšinė įvairovė, ekonomiškai, mediciniškai ir ekologiškai svarbias bestuburių gyvūnų rūšys. Apžvelgiama bestuburių svarba vertinant aplinkos būklę. Aptariamos retosios ir nykstančios bestuburių rūšys, analizuojami faktoriai, nulemiantys šių rūšių išsaugojimą.

Short course annotation in English (up to 500 characters)

This course is designed to provide students with a basic understanding of biology, morphology, anatomy and physiology of the more common invertebrate phyla. This course is intended to introduce students with knowledge on structure, functional processes and diversity of protozoa and metazoa invertebrates. The characteristics (principles of feeding, behavior, reproduction, adaptations to various environments) of the main groups of invertebrates will be analyzed. The taxonomy, distribution, diversity and economical, medical and ecological importance of invertebrates will be presented. The rare species of invertebrates and factors important for the conservation invertebrate species will be observed.

Relevance of the course

Invertebrate Zoology is one of the most important natural science study subjects analysing the structure, biology, diversity and systematic structure of invertebrate animals and their relationship with other components of living and non-living nature. Invertebrates constitute for about 95 percent of the total number of species and individuals of wildlife of the Earth. They are common in all biocenoses and occupy a very important place in nature and human life. A variety of invertebrate animals ranging from unicellulars to molluscs and echinoderms are examined in the course. Students consistently examining systematic groups of invertebrate animals, understand the main directions of the evolutionary process and the structural and functional adaptations that have emerged during this process. While studying this subject, students will know the systematics of unicellular and multicellular invertebrates, the representatives of main types, their morphology, bioecology, the principles of their monitoring and protection, and forms of relationships between living organisms. Understanding of nature conservation problems and the necessity of biodiversity preservation will be indoctrinated. Ability to identify and characterize the main invertebrate animals, explain their biology peculiarities, performance of accounting, responsibility in making

necessary decisions regarding the environmental factors and environmental protection requirements will be elevated.

Course aims

Preparation of theoretically qualified, capable of critical and creative thinking, broad-based students with knowledge and skills in the fields of biology, ecology, agronomy, and the environment, and capable in adapting this knowledge and skills in their professional activity under the altering environment conditions.
To construct the system of theoretical knowledge of living and non-living nature and cognition of ecosystems, to improve abilities of application of mathematical methods and information technologies, to develop skills in assessment and application of protection measures of individual components of nature.
To provide students with knowledge of evolution, systematics, morphology, their interrelations, significance, ecology of invertebrate animals; to study in detail the invertebrates living in Lithuania (protozoa, worms, arthropods, molluscs), their phylogeny, behavior, structure, ecology, methods of protection and control.

Content (topics) and methods

Content of the subject:

Lectures:

1. History of Zoology, taxonomy. Overview of living organisms. Animal Kingdom. Location and significance of invertebrates in ecosystems.
2. Structure, systematics of unicellular animals. The most important representatives, their ecology, significance.
3. Types of Sarcodina, Flagellata, Sporozoa, Cnidosporidia, Microsporidia, Ciliophora (structure, systematics, ecology, phylogeny).
4. Subkingdom of Multicellulars (structure, development, taxonomy).
5. Subsections of Phagocytelozoa, Parazoa (types of Placozoa, Spongia), key representatives, ecology, significance.
6. Eumetazoa (types of Coelenterata and Ctenophora), key representatives, ecology, significance.
7. Section of Bilateralia. Types of Plathelminthes, Nemathelminthes, and Annelida worms. Systematics, ecology, and significance.
8. The main representatives of the types of Nemertini, Rotatoria, Cephalorhyncha, Acanthocephala, Echiurida, Sipunculida. Their significance and ecology.
9. Types of Onychophora, Tardigrada, Tentaculata, Branchiopoda, Hemichordata, Pogonophora, Chaetognatha, Echinodermata. Their classification, morphology, ecology.
10. Type of Mollusca. Systematics, ecology, and significance.
11. Type of Arthropoda. Subtypes of Chelicerata, Trilobitomorpha, Pantopoda. Their systematics and ecology.
12. Class of Arachnida. Their systematics, ecology, and significance.
13. Subtype of Branchiata. Class of Crustacea. Systematics, ecology, and significance.
14. Subtype of Tracheata. Class of Myriapoda. Systematics, ecology, and significance.
15. Class of Insecta (morphology, behavior, reproduction and development, ecology).
16. Systematics and significance of insects.
17. Research methods, monitoring, and bioindication of invertebrate animals.
18. Control and protection problems of invertebrate animals.

Seminars:

1. Systematics and protection of unicellular animals.
2. Spongia, Coelenterata and their protection.
3. Worms.
4. Arthropoda. Subtype of Chelicerata.
5. Subtype of Branchiata.

6. Insect structure, larvae, pupae.
7. Insect systematics.
8. Mollusca, Echinodermata.
9. Coral reef protection.

Traditional and innovative study methods are used to convey the subject content. Traditional study methods are represented by a classical lecture (examination of various topics). Material of the lecture is visualized using multimedia equipment, video equipment. During the sessions, part of the time is devoted to students' speeches and discussions. Practical tasks include assignments using animal samples, their preparations or pictures. Students perform tasks independently using exercise descriptions, identification keys, collections, and in consultation with the teacher. During the practical work each student has the opportunity to use the microscope individually. A video camera connected to a microscope and computer equipment is used for demonstration of particular work stages.

Presentation (defence) of practical work results is mandatory.

Structure of cumulative score and value of its constituent parts

The 10-point cumulative assessment structure is applied, following the criteria for assessing the subject's learning outcomes. The quality of laboratory work is evaluated according to the quality of individual work as well as the quality of the answers to the questions and the ability to discuss. During the control work, students respond to test questions by selecting one of the 3 answers given, recognizing 10 samples of animals or their paintings, indicating their taxonomy. The quality of practical work is assessed by the quality of individual work as well as the quality of the answers to the questions and the ability to discuss. During the exam, problematic questions requiring short answers are presented. Exam is the final assessment of the student's knowledge, and only those who have assessments of their independent work have the right to attend it.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Kazlauskas R. Bestuburių zoologija. Vilnius, 1988, 384 p.
2.	Žiogas A. Bestuburių zoologija ir apsauga. Mokomoji knyga. Akademija, 2009. 95 p.
3.	Edward E. Ruppert. Invertebrate Zoology: A Functional Evolutionary Approach Sinauer Associates, 2009.
4.	Hill R.W., Wyse G.A.,Anderson M. Animal Physiology Sinauer Associates, 2004.
5.	Ruppert E.E., Barnes R.D. Invertebrate zoology. Sixt edition. Saunders College Publishing 1991.112 p.
6.	Brusca R. C., Brusca G. J. Invertebrates. Sinauer Associates, 2003.
7.	Mažiulis D., Starodubaitė M. Zoologija.- Vilnius; Siveida, 2001. 296 p.
8.	Догель В. А. Зоология бензпозвоночных М. 1981.
9.	Thorp J. H., Covich A.P. Ecology and Classification of North American Freshwater Invertebrates, (Aquatic Ecology) The McDonald and Woodward Publishing Company Blacksburg, Virginia, 2002.
10.	Invertebrate zoology (CD-ROM). Mac/Win CD-ROM/2001/ 27AW2288
11.	Kingdom Animalia: The invertebrates. /DVD/ 2005/27AW2789
12.	Kingdom Animalia: The invertebrates. /DVD/ 2005/27AW2789

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Gecevičiūtė S. Bestuburių zoologijos laboratorinių darbų atlikimas. Vilnius, 1994.
2.	Invertebrate zoology. Peer-reviewed journal. KMK Scientific Press Ltd. Moscow. Volume 1 – 9, 2010, 2011, 2012.
3.	Kublickienė O. Parazitiniai pirmuonys. Mokomoji knyga aukštųjų mokyklų studentams. Vilniaus universiteto leidykla. 2000. 86 p.
4.	Lešinskas A., Pileckis S. Vadovas Lietuvos vabzdžiams pažinti. – V: Mintis, 1967.- 372 p.

5.	A. Žiogas, D. Zakarauskaitė. Dirvožemio biologija. Mokomoji knyga. 2010. 136 p/
6.	A. Žiogas. Agriocenozių bioindikacija ir apsauga/ Mokomoji knyga, 2012, 191 p.
7.	Rašomavičius V., editor. Red data book of Lithuania (Lietuvos Raudonoji knyga). Kaunas: Lututė, 2007. 800 p. (in Lithuanian).
8.	Helsdingen van P.J Background information on invertebrates of the Habitats Directive and the Bern Convention. Strasbourg: Council of Europe Publishing, 1996.
9.	Haslett J. R. European strategy for the conservation of invertebrates: Convention on the Conservation of European Wildlife and Habitats (Bern Convention). Strasbourg: Council of Europe Publishing, 2007.
10.	Raudonikis L. Europos Sąjungos Buveinių direktyvos saugomos rūšys: vadovas Lututė, 2006.
11.	Lynn D. H. The ciliated protozoa. Springer, 2007. Šatkauskienė I. Gėlųjų vandenų bestuburiai. VDU leidykla, 2004.
12.	Šatkauskienė I. Gėlųjų vandenų bestuburiai. VDU leidykla, 2004.
13.	Жизнь животных. В 7 т. Том первый. Простейшие – щупальцевые. Москва. Просвещение,1987. – 448 с.
14.	Жизнь животных. В 7 т. Том второй. Молюски – ракообразные. Москва. Просвещение, 1988. – 447 с.
15.	Жизнь животных. В 7 т. Том третий. Членистоногие – онихофоры. Москва. Просвещение, 1984. – 463 с.

Course programme designed by

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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8001	8	VMU AA	Agronomy	Agroecosystems and Soil Science

Course title in Lithuanian

Agronominių tyrimų planavimas ir analizė

Course title in English

Agronomy Research Methodology

Study methods	Volume in ECTS credits
Lectures	2
Consultations	1
Practicums	1
Individual work	4

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas pirmųjų metų doktorantams. Dalyko tikslas – suteikti doktorantams agronominio mokslinio tyrimo savarankiško planavimo, atlikimo, duomenų statistinės analizės, rezultatų vertinimo ir interpretavimo žinių ir ugdyti gebėjimus, reikalingus rengiant daktaro disertaciją ir toliau savarankiškai dirbant mokslinį darbą. Dalyko studijų formos: paskaitos, pratybos, konsultacijos, pasirengimas kontroliniam darbui, individualiosios užduoties atlikimas, pasirengimas egzaminui.

Short course annotation in English (up to 500 characters)

The subject is delivered for the first year PhD students. The aim of the course is to provide PhD students with knowledge and abilities of autonomous agronomic research planning, statistical evaluation and interpretation of the research results. These knowledge and abilities are important in doing research and writing PhD degree theses and in future autonomous research work. The studies of the subject include lectures, practicums, consultations, preparation for intermediate test, completion of individual assignment, preparation for examination.

Relevance of the course

The course helps for PhD students to plan, conduct investigation, make statistical analyses of research data, compile conclusions, write publications and PhD theses.

Course aims

To know agronomic research methods, to understand the theoretical aspects of designing, conducting research in agronomy and analysing of research data, to acquire skills in designing experiments and statistically analysing research results.

Content (topics) and methods

Lectures

1. Introduction. Science and its role, unity of research planning and statistical analysis.
2. Agronomic Research Methods: advantages and disadvantages.
3. Types of experiments, their advantages and disadvantages.
4. Sources of scientific information and how to find them.
5. Research process and it’s planning.
6. Experiment planning: theoretical and practical aspects.
7. Population and sample: concepts and statistical indicators.
8. Statistical distributions and their application in experimental statistics.
9. Testing of null hypothesis.
10. Assumptions of ANOVA and regression analysis. The research data transformation.

11. Application of ANOVA for the assessment of agronomic research data.
12. Regression and correlation analysis application for the assessment of agronomic research data.
13. Application of cluster analysis and principal component analysis (PCA) for the assessment of agronomic research data.
14. Presentation of statistical analysis results in the scientific publications.
15. Writing of research publications and theses.

Practicums

1. Sample statistical indicators, confident interval and *t* test.
2. Assumptions of statistical analysis and data transformation.
3. Single and multi-factor ANOVA.
4. Regression and correlation analysis.

Methods of learning

Lectures, practical works, individual task (the methodology or PhD research work), individual consultations, student's independent work.

Structure of cumulative score and value of its constituent parts

The final assessment consists of practicums - 20%, individual task - 20%, interim assessment (colloquium) - 20%, exam - 40%.

Reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Onofri A., Sacco D. Experimental methods in agriculture. 2021. https://www.statforbiology.com/_statbookeng/
2.	Hoshmand A. R. Design of experiments for agriculture and the natural sciences. – Chapman & Hall/CRC, USA, 2006
3.	Mokslinės metodikos inovatyviems žemės ir miškų mokslų tyrimams. Kaunas, Lututė, 2013
4.	Kardelis K. Mokslinių tyrimų metodologija ir metodai (penktasis leidimas), 2016
5.	Raudonius S. Mokslinių tyrimų planavimas ir analizė. – Akademija, 2008
6.	Gijsbers G., Janssen W., Hambly Odame H., Meijerink G. Planning Agricultural Research. A Source book. International Service for National Agricultural Research (ISNAR). The Hague, The Netherlands. 2001
7.	Latwal G. S. Research Mthodology. I.K.International. Pvt. Ltd. 2020
8.	Palaniswamy U. R., Palaniswamy K. M. Handbook of statistics for teaching and research in plant and crop science, USA, The Haworth Press, Inc., 2006
9.	Rowena M. How to write a theses.-Great Britain, Open University Press, 2003
10.	Welham S. J., Gezan S. A., Clarks. J., Mead A. Statistical Methods in Biology: Design and analysis of Experiments and Regressions, CRC Press, 2015.
11.	Wu J. and Hamada M. S. Experiments: planning, analysis, and optimization. Wiley Series in Probability and Statistics, 2009
12.	Greenacre, M., Groenen, P.J.F., Hastie, T. et al. Principal component analysis. Nat Rev Methods Primers 2, 100 (2022). https://doi.org/10.1038/s43586-022-00184-w
13.	Tan P.N., Steinbach M., Karpatne A., Kumar V. 2019. Introduction to Data Mining. Pearson Education, Inc., New York
14.	Raudonius, Steponas. Application of statistics in plant and crop research: important issues // Žemdirbystė = Agriculture / Lietuvos agrarinių ir miškų mokslų centras, Aleksandro Stulginskio universitetas. Akademija, T. 104, Nr. 4 (2017), p. 377-382.
15.	Velička R., Raudonius S., Marcinkevičienė A., Trečiokas K. Lauko bandymų planavimas ir atlikimas. Metodinė priemonė. – Akademija, 2004
16.	Piepho H.P., Edmondson R.N. A tutorial on the statistical analysis of factorial experiments with qualitative and quantitative treatment factor levels. J Agro Crop Sci. 2018;204:429–455. DOI: 10.1111/jac.12267

17.	Petersen R. G. Agricultural Field Experiments. Taylor and Francis Group, 1994.

Course programme designed by

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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8002	8	VMU AA	Agronomy	Agroecosystems and Soil Sciences

Course title in Lithuanian

Žemės ūkio augalų produktyvumo biologija

Course title in English

The Biology of Crop Productivity

Study methods	Volume in ECTS credits
Lectures	4
Consultations	1
Individual work	3

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas pirmųjų metų doktorantams. Dalyko tikslas – suteikti doktorantams žinių apie naujausius augalų produktyvumo biologijos mokslo pasiekimus ir ugdyti gebėjimus interpretuoti agronominio mokslinio tyrimo rezultatus, modeliuoti augalų produktyvumą ir produkcijos kokybę, ugdyti gebėjimus, reikalingus rengiant daktaro disertaciją ir toliau savarankiškai dirbant mokslinį darbą. Dalyko studijų formos: paskaitos, pratybos, konsultacijos, seminarai, pasirengimas kontroliniam darbui, individualiosios užduoties atlikimas, pasirengimas egzaminui.

Short course annotation in English (up to 500 characters)

The subject is intended for first-year PhD students. The aim of the subject is to provide doctoral students with knowledge about the latest achievements in crop productivity biology and to develop skills to interpret the results of agronomy research, model crop productivity and product quality, develop skills required for Doctoral Dissertation and further independent research. Forms of study of the subject: lectures, exercises, consultations, seminars, preparation for control work, performance of individual task, preparation for an exam.

Relevance of the course

The subject helps PhD students to plan, model and perform research, select appropriate research methods to determine plant productivity, to interpret and summarize the obtained research results, formulate conclusions, prepare scientific publications and Doctoral Dissertation.

Course aims

To provide knowledge of the latest achievements of biology of crop productivity and abilities to interpret the results of agronomy research, to model crop productivity and production quality; to identify morphogenetic, organogenetic, phenological and physiological parameters of plant ontogenesis associated with crop productivity.

Content (topics) and methods

Lectures:

1. Factors influencing the productivity of agricultural crops:

1.1. A general knowledge about the plant yield.
1.2. Botanical peculiarities of agricultural plants.
1.3. Ontogenesis of agricultural plants.
1.4. The genetic determination of the productivity.
1.5. Plant resistance to biotic and abiotic factors.
1.6. Whole plant biology.
1.7. Physiology of plant productivity.
1.8. The plant yield, harvest index, modelling.

2. Biological peculiarities of agricultural plants:
2.1. Biology of vegetable productivity.
2.2. Biology of orchard productivity.
2.3. Biology of Poaceae crop productivity.
2.4. Biology of Fabaceae crops productivity.
2.5. Biology of rapeseed productivity.
2.6. Biology of sugar beet productivity.
2.7. Biology of potato productivity.

Study methods:
Lectures are given using a problematic, visualized teaching method, visualizing the material using multimedia and a whiteboard. If necessary, lectures are given remotely using remote meeting software (MS Teams, Zoom, etc.). During the lectures, the methods of case analysis and brainstorming are applied. Students participate in discussions individually or in groups. The groups are also given tasks based on the researched material, they prepare and present the completed tasks. A discussion is organized after each presentation. Each doctoral student receives an individual task: based on the acquired knowledge, agrobiological laws and regularities, the PhD student biologically substantiates the hypothesis of his / her scientific dissertation topic, the provisions formulated in the goal and objectives and makes a public presentation. Students review each other's individual tasks, assess the validity of the hypothesis and research tasks. During the practicums, PhD students are introduced to crop productivity research methods, scientific laboratories and advanced research laboratory equipment. PhD students formulate conclusions drawn from the results of the tasks performed. They present the results of practicums using computer programs. PhD students are additionally consulted according to the agreed schedule and by IT tools. In the absence of a minimum number of PhD students, subject studies are organized through consultations.

Structure of cumulative score and value of its constituent parts

A criterion ten-point scale and a cumulative assessment system are used to assess student achievement.
Assessments are performed in accordance with the provided criteria for the assessment of the study results of the subject. The final assessment consists of: control work – 25%, individual task – 25%, exam – 50%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Šlapakauskas V., Duchovskis P. Augalų produktyvumas. LŽŪU, 2007, 253 p.
2.	Šlapakauskas V. Augalų ekofiziologija. K.: Lututė, 2006, 430 p.
3.	Fageria N. K., Baligar V. C., Clark R. B. Physiology of crop production. USA, Food Product Press, 2006, 345 p.
4.	Fitter A. H., Hay R. Environmental physiology of plants. S. D., S. F., N. Y., B. L., S.T. Academic press, 2002, 367 p.
5.	Hay R., Porter J. The physiology of crop yield. Blackwell publishing, UK, USA, Australia, 2006, 314 p.
6.	Srivastava L. M., Lalit M. Plant growth and development hormones and environment. Amsterdam : Academic Press, 2002, 795 p.
7.	Chong K., Palanivelu R., Zhao D. Molecular and cellular plant reproduction. Frontiers Media SA, 2017, 302 p.
8.	Ahmad P. (Ed.). Photosynthesis, productivity and environmental stress. Hoboken N. J. Wiley Blackwell, 2020, 368 p.
9.	Campbell A. M., Paradise C. J. Photosynthesis. New York: Momentum Press, 2016, 54 p.
10.	Roychoudhury, A., Tripathi D. (Eds.). Molecular plant abiotic stress : biology and biotechnology. Hoboken N. J., John Wiley, 2019, 454 p.

11.	Opalko A. I., Weisfeld L. I., Bekuzarova S. A., Bome N. A., Zaikov G. E. (Eds.). Ecological consequences of increasing crop productivity : plant breeding and biotic diversity, New York: Apple Academic Press, 2015, 328 p. https://doi.org/10.1201/b17477
12.	Kaur T., Arora, S. (Eds.). Environmental stress physiology of plants and crop productivity. Sharjah, UAE: Bentham Science Publishers, 2021, 243 p.
13.	García Cañedo J. C., López-Lizárraga, G. L. (Eds.). Photosynthesis : from its evolution to future improvements in photosynthetic efficiency using nanomaterials. London: IntechOpen, 2018, 122 p.
14.	Carlson P. S. (Ed.). The Biology of crop productivity. New York: Academic Press, 1980, 490 p.
15.	Ashraf M., Philip Harris P. J. C. (Eds). Abiotic stresses. Plant resistance through breeding and molecular approaches. Boca Raton: CRC Press, 2005, 766 p.
16.	Rupaitienė O. Trumpas anglų-lietuvių ir lietuvių-anglų augalų biologijos terminų žodynas. Vilnius: UAB „Nacionalinių tyrimų centras“, 1998, 432 p.
17.	Mengel K., Kirkby E. A. Principles of plant nutrition. Springer Netherlands, 2012, 849 p.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Bluzmanas ir kt. Augalų fiziologija. V.: Mokslas, 1991, 420 p.
2.	LAMMC, VDU / Zemdirbyste-Agriculture (periodinis mokslo žurnalas).
3.	Lietuvos mokslų akademija / Žemės ūkio mokslai (periodical scientific journal).
4.	Lietuvos mokslų akademija / Biologija (periodical scientific journal).
5.	Stašauskaitė S. Augalų vystymosi fiziologija. Vilnius: Debesija, 1995, 98 p.
6.	Taiz L., Zeiger E. Plant physiology. California: The Benjamin Cumings publ. Company, 2002. 690 p.
7.	Plant biology research and training for the 21st century. Washington, D.C: National Academy Press, 1992, 79 p.
8.	Sage R. F., Monson, R. K. C4 plant biology. San Diego: Academic Press, 1999, 616 p.
9.	Young A., Britton, G. (Eds.). Carotenoids in photosynthesis. Dordrecht: Springer Netherlands, 1993, 498 p. https://doi.org/10.1007/978-94-011-2124-8
10.	Janick J. (Ed.). Plant breeding reviews. Volume 38. Hoboken, New Jersey: Wiley Blackwell, 2014, 329 p.
11.	Mooney H. A., Roy, J., Saugier B. Terrestrial global productivity. San Diego, Calif: Academic Press, 2001, 597 p.

Course programme designed by

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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

DESCRIPTION OF THE DOCTORAL STUDY
SUBJECT OF AGRONOMY SCIENCES FIELD

Administrator of doctoral study program: Vytautas Magnus University Agricultural Academy and Lithuanian Research Centre for Agriculture and Forestry
Code of the study subject: AGR8003
Title of the study subject: in Lithuanian
***Ag*roekologija**
Name in English: Agroecology
Number of ECTS credits: 7 (187 h, including 46 h of contact work and 141 h of independent work)
Dalyko anotacija lietuvių kalba
Agroekologijos samprata. Agroekosistemų principai, raida ir valdymas. Žemės ūkio augalų biocenozės ryšiai ir juos įtakojantys aplinkos veiksniai. Kintančio klimato ir dirvožemio agroekologinė reikšmė žemės ūkio gamybai. Pagrindinės šiandieninio žemės ūkio sąlygojamos agroekologinės problemos. Darnaus vystymosi koncepcija. Šiuolaikinių žemdirbystės sistemų vertinimas ilgalaikio ekologiškai stabilaus funkcionavimo požiūriu.
Dalyko anotacija anglų kalba
Agroecology concept. Fundamentals, development and management of agro-ecosystems. Relation of agricultural plant biocenosis and environmental factors affecting them. Agroecological significance of changing climate and soil for agricultural production. Major agroecological problems caused by today's agriculture. The concept of sustainable development. Assessment of modern farming systems in terms of long-term ecologically stable functioning.

Forms and volume of work:

Forms of contact work	***Hours***	***Forms of independent work***	***Hours***
Lectures	42	Preparation for the test	26
Consultations	2	Preparation of an essay	35
Examination	2	Preparation for the exam	80

The purpose of the subject:

Study cycle	***Study programme***	***Subject type***
Third	Agronomy	Optional

Objective of the study subject: on the basis of the obtained knowledge, to assess the concepts, principles, development and biocenotic relationships of the ecosystems and agricultural systems as well as the effects of external conditions on the formation of these relationships.
Qualifications necessary for enrolment on the study programme: master's degree in agricultural sciences (preferably in agronomy (01 A) or a single-cycle higher education degree.
Outcomes of the study programme:
Knowledge and its application: a PhD student knows and is able to apply: the concept, structure and functioning of agro- and eco-systems and their management possibilities, the anthropogenic effect on the formation of agroecological problems and solutions to these problems, the role of agricultural intensity in shaping general ecological status of the country, biosphere, water, air and soil resources, their pollution and protection, integrated application of the related fundamental and the latest knowledge of different branches of science.
Capacity to carry out research: to identify agroecological problems and their causes, to select the appropriate cause and effect assessment methods for the analysis of agroecological problems, to

generate novel, original ideas, solutions and conclusions based on theoretical and practical data from agroecological experiments.

Special competences: to demonstrate agroecological understanding of the agricultural activity, to interpret agroenvironmental decisions, to understand the interface between man and environment, to scientifically assess the processes of the agroecosystem; to select rational, agricultural systems management practices/methods based on the original scientific research data, to describe energy cycling, biocenotic relationships and conditions for their control in the agroecosystem, to estimate the impact of changing climate on the agroecosystems and their adaptive capabilities, to plan sustainable use of genetic resources of agroecosystems and ecosystems.

Social skills: to be able to communicate with colleagues, scientific community and the public while developing and transferring innovations of their activity field; to perceive mankind as a factor which has the greatest environmental impacts; to foster technical, social and cultural progress favouring the development of society.

Personal skills: take responsibility to fully appraise, solve and creatively develop the problematic aspects of the subject area; be able to reveal and develop creative intellectual personal capabilities; be able to think creatively, critically and self-critically and to make use of various original concepts and information.

Assessment criteria of the subject study results:

1. Knowledge of the theoretical and practical aspects of the agroecology science and ability to apply them.
2. Understanding of social, ecological, and economic consequences of agricultural industrialization.
3. Ability to identify the demands and prospects of sustainable food production system; the role of different-intensity agriculture in the overall ecological status of the country and possibilities to improve it.
4. To summarize the agroecological significance of climate and soil for agricultural production on the global and local scale.
5. Ability to manage the complexity of environmental factors, to adapt the regularities of population processes in the agroecosystems.
6. Ability to evaluate biospheric resources, identify and rationally use genetic resources of the ecosystems and agroecosystems.
7. Ability to simulate energy flows of the agroecosystem.
8. Ability to combine, summarize and integrate the knowledge of different fields of science.
9. Ability to personally develop, project further prospects of learning, take responsibility to critically assess strategic decisions of his/her area of activity, ability to reveal and develop personal creative and intellectual competences.

Course content:

Lectures:

1. Introduction to the agroecology.
2. Evolution of the agroecology. Agroecology as a separate branch of science.
3. Agroecological problems.
4. Concept of agroecology.
5. Effects of climate and its change on the agroecosystems.
6. Soil and land assessment and protection.
7. System-level agroecological interactions.
8. Agricultural crops and environmental factors. External conditions for the formation of plant biocenotic relationships.
9. Agroecological role of animal husbandry.
10. Genetic resources of agroecosystems.

11. Energetics of agroecosystems.

Study methods: use of multimedia equipment and/or a graphic projector in lectures, the lecture material is illustrated by slides. Individual work. Each PhD student is given an individual task for systemic analysis on the basis of which essay is prepared.

The written essay is presented verbally in the form of a scientific discussion. The presentation is followed by a discussion. Control work/test is done in writing or verbally (when no group of PhD students is present). Control work is designed to check the student's knowledge and competences upon completion of the part of the study programme. Besides answering theoretical questions, a student describes agroecological problems and provides an analysis of problem solution methods and implementation possibilities, which show the PhD student's ability to creatively and independently apply the knowledge and formulate targeted solutions. At a scheduled time, PhD students are additionally consulted directly or in the cyberspace.

If there is no minimal number of students necessary for delivering a lecture, the studies are organized in the form of consultations. An individual timetable of consultations is made. A student individually studies the literature indicated by the lecturer. At a time scheduled for each subject's topic, a direct consultation is arranged to estimate the student's achievements and to explain the questions that need extra attention and to clarify the essential aspects of the topics under analysis.

Methods and structure of cumulative assessment of students' achievements: a ten-point scale criterion and cumulative assessment scheme are applied. Scientific discussions are encouraged. Tasks of independent work during the semester – essay (written and verbal presentation) and individual control work/test (in writing or verbally) – assessed by giving marks, final assessment is determined during the exam by multiplying the mid-term assessments by the weighting factor and by adding the products. The assessment point is determined according to the PhD student's ability to comprehensively and systematically analyse the given problematic questions and to participate in the interdisciplinary discussions. The assessment of student's knowledge and competences during the exam (oral examination) and the final assessment are done by the commission composed of three members: a lecturer coordinating the subject studies, a lecturer, and a supervisor or consultant of the student.

Structure of cumulative assessment:

Work forms	***Weighting factor***	***Scheduled dates***
Test/control work	0.10	8th week
Essay	0.20	10th week
Exam	0.70	17th -20th week

Major sources of study:

1. Agroekosistemų komponentų valdymas. Sudaryt. Tripolskaja L. ir kt. Akademija, Kėdainių r., 2010. 568 p.
2. Brazauskienė D. Agroekologija ir chemija. K., Naujasis lankas, 2004. 207 p.
3. Gliessman S.R. Agroecology: The Ecology of Sustainable Food System. CRC Press, New York, 2007. 384 p.
4. Lazauskas P., Pilipavičius V. Agroekologija. Mokomoji knyga. LŽŪU, Akademija. UAB „IDP Solutions“ 2008. 133 p.
5. Marozas V. Sausumos ekosistemų įvairovė ir apsauga. Vadovėlis. LŽŪU. UAB "IDP Soliutions". 2008. 246 p.
9. Scientific journals – Agriculture, Ecosystems and Environment; Agricultural Systems; Journal of Applied Ecology; Agronomy for Sustainable Development; European Journal of Agronomy ir kt.
10. Newton P.C.D., Carran R.A., Edwards G.R., Niklaus P.A. Agroecosystems in a Changing

Climate. CRC Press, USA. 2007. 364 p.
11. Wojtkowski P. A. Introduction to Agroecology: Principles and Practices. 2006. 403 p.

Additional sources of study:

1. Altieri M.A. Agroecology. Westview Pres, 1995. 431 p.
2. Baltrėnas P., Lygis D. ir kt. Aplinkos apsauga. Enciklopedija. V., 1996. 287 p.
3. Bučienė A. Žemdirbystės sistemų ekologiniai ryšiai (monografija). Klaipėda: LKU leidykla, 2003. 176 p.
4. Jankauskas B. Dirvų apsauga nuo erozijos. Vilnius. 1990.
5. Kormondy J.E. Ekologijos sąvokos. Litera Universitati Vytauti Magni. 1992. 320 p.
6. Lietuvos žemės našumas. Sudarytojas Mažvila J. Akademija, Kėdainių r., 2011. 280 p.
7. Mokslinės duomenų bazės – Web of Science; Science direct; Agricola, ir kt.
8. Nadzeikienė J. Aplinkos apsaugos inžinerija. Mokomoji knyga. Aleksandro Stulginskio universitetas. Akademija, Kauno r., 2012. 120 p.
9. Ozolinčius R. Aplinkos ištekliai. Kaunas, VDU leidykla. 2005. 211 p.
10. Pilipavičius V., Navickas K. Atsinaujinantys agrariniai ištekliai ir atliekų perdirbimas. Mokomoji knyga. LŽŪU, Akademija. UAB „IDP Solutions“ 2008. 142 p.
11. Pilipavičius V., Pupalienė R., Marcinkevičienė A. Pasėlių bendrijos ir jų tyrimai. Mokomoji knyga. LŽŪU, Akademija. UAB „IDP Solutions“ 2008. 112 p.
12. SOER 2015 — The European environment — state and outlook 2015. [interaktyvus] [žiūrėta 2016 m. sausio 18 d.]. Prieiga per internetą: < http://www.eea.europa.eu/soer >
13. Stravinskienė V. Ekologijos įvadas. K., 2001. 155 p.
14. Stravinskienė V. Bendroji ekologija. K., 2003. 232 p.
15. Tausojamoji žemdirbystė našiuose dirvožemiuose. Sudarytoja Maikštėnienė S. Akademija, Kėdainių r., 2008. 327 p.
16. Tittonell P, Piñeiro G, Garibaldi LA, Dogliotti S, Olff H and Jobbagy EG. (2020) Agroecology in Large Scale Farming—A Research Agenda. Front. Sustain. Food Syst. 4:584605. doi: 10.3389/fsufs.2020.584605
17. Velička R., Pupalienė R. Demografinės padėties, klimato kaitos ir agroekologijos sąsajos. mokomoji knyga. LŽŪU, Akademija, 2010. 98 p.

Course programme designed by

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Approved in the meeting of the programme's Doctoral Studies Committee on October 16, 2024, by Resolution No. 218.

Description of the subject has been certified until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8004	7	VMU AA	Agronomy	Plant Biology and Food Sciences

Course title in Lithuanian

Žemės ūkio augalų biotechnologija

Course title in English

Biotechnology of Crops

Study methods	Volume in ECTS credits
Lectures	2,0
Consultations	-
Seminars	1,5
Individual work	3,5

Short course annotation in Lithuanian (up to 500 characters)

Perteikiamos bazinės ir naujausios žinios apie augalų biotechnologiją. Dalykas skirtas giliau suprasti augalų izoliuotų organų, audinių ir ląstelių auginimo savitumus *in vitro* sistemoje, didžiausią dėmesį skiriant naujausiems šio mokslo pasiekimams, žemės ūkio augalų biotechnologinių metodų panaudojimo praktikoje galimybėms bei jų reikšmei įvairių mokslų ir visuomenės vystymosi kontekste.

Short course annotation in English (up to 500 characters)

Basic and advanced knowledge on plant biotechnology are included. The subject intendent for a deeper understanding peculiarity of isolated organs, tissues and cells in *in vitro* system. The greatest attention is paid on the most recent achievements in plant biotechnology, agricultural plant biotechnological methods used in practice and their implications for the various sciences and social development.

Relevance of the course

Creation of plant genetic diversity by traditional breeding methods is a long and difficult process based on intervarietal hybridization and selection of the best plants. The development of genetic diversity all around the world progressively increases in the applying of *in vitro* and molecular technologies with leads to create varieties not only with new characteristics (improved quality parameters, resistance to diseases, herbicides, etc.), but also to reduce the period of time required to develop genetically stable lines. The theoretical knowledge and practical skills of plant biotechnology are very relevant for the research in the field of agronomy using biotechnological methods.

Course aims

Provide students with knowledge about the latest achievements in agricultural plant biotechnology, about importance of isolated organs, tissues and cell cultures, molecular markers in today's crop production and peculiarity in employment of biotechnological methods for breeding programs of different plant species in order to increase the efficiency of breeding work.

Content (topics) and methods

A plant biotechnology methods, directions and tasks. Conditions, principles and application possibilities of the higher plants isolated organs, tissues and cells cultures. Methods of micropropagation *in vitro*. Commercial aspects of micropropagation. *In vitro* technology in plant breeding. Creation of haploids and homozygous lines. Development of polypoid and mutants. Cell breeding. The secondary metabolic compounds *in vitro*. Storage of genetic plasma *in vitro*.

Gene engineering. Genetically modified plants. GMO risk assessment and legislation. Genome editing.

Methods.

Explanatory - demonstration method, discussion, self-learning using additional material, individual presentation of the assignment. If doctoral students studying the subject are less than three, lectures are not delivered. In this case, the doctoral students, in consultation with teachers, self-studying the latest scientific literature and prepared an individual assignment in the doctoral dissertation topic. Consultation arranged in accordance with a pre-arranged schedule.

Structure of cumulative score and value of its constituent parts

Individual work – 20%, seminars – 30%, exam – 50% of final knowledge assessment.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Chrispeels M. J., Sadava D. E. *Plants, genes and crop biotechnology*. Jones and Bartlett Publisher, 2002, 562 p.
2.	Christou P. *Handbook of Plant Biotechnology*. Wiley, 2004, 1488 p.
3.	Coleman J., Evans D., Kearns A. *Plant cell culture*. Garland science, 2003, 208 p.
4.	Plant biotechnology and agriculture [elektroninis išteklius]: prospects for the 21st century / edited by A. Altman, P. M. Hasegawa. Amsterdam; Boston: Academic Press, 2012, 586 p.
5.	Plant mutation breeding and biotechnology / edited by Q. Y. Shu, B. P. Forster, H. Nakagawa. Wallingford, Oxfordshire; Cambridge, Mass.: CABI, 2012, 608 p.
6.	Transgenic crops IV / edited by E. C. Pua, M. R. Davey. Berlin: Springer, 2007. 476 p.
7.	From plant genomics to plant biotechnology / edited by P. Poltronieri, N. Burbulis, C. Fogher. Cambridge : Woodhead Publishing Limited, 2013, 242 p.
8.	Ratledge C., Kristiansen B. *Basic biotechnology*. Cambridge University Press, 2006, 666 p.
9.	Slater A., Scott N. W., Fowler M. R. *Plant biotechnology*. *The genetic manipulation of plants*. Oxford university Press, 2004, 346 p.
10.	Malik Zainul Abdin, Usha Kiran, Kamaluddin, Athar Ali. Plant Biotechnology: Principles and Applications. 2017. Springer. doi.org/10.1007/978-981-10-2961-5
11.	Shabir Hussain Wani, Goetz Hensel (ed.). Genome Editing 2022. Springer Cham. doi.org/10.1007/978-3-031-08072-2

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Atherton K. *Genetically modified crops*. Taylor & Francis Ltd, 2002, 272 p.
2.	Cassells A. C., Gahan P. B. *Dictionary of plant tissue culture*. An Imprint of The Haworth Press, 2006, 265 p.
3.	Zeba Khan, Durre Shahwar, Yasmin Heikal. (ed.) Genome Editing and Global Food Security Molecular Engineering Technologies for Sustainable Agriculture. London, 2023. https://doi.org/10.4324/9781003382102

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Natalija Burbulis	VMU AA	Prof. Dr.	natalija.burbulis@vdu.lt
2.	Aušra Blinstrubienė	VMU AA	Prof. Dr.	ausra.blinstrubiene@vdu.lt
3.	Vidmantas Stanys	LRCAF	Prof. Habil. Dr.	vidmantas.stanys@lammc.lt

Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8005	7	VMU AA	Agronomy	Agroecosystems and Soil Sciences

Course title in Lithuanian

Dirvotyra

Course title in English

Soil Science

Study methods	Volume in ECTS credits
Consultations	1
Individual project	2
Individual work	4

Short course annotation in Lithuanian (up to 500 characters)

Studijuodami dalyką „Dirvotyra“ doktorantai įgyja žinių apie dirvožemio svarbą žemės ūkio ir miško ekosistemose, supranta geologinius ir mineralų dūlėjimo procesus bei dirvodaros veiksnius, adaptuoja ir taiko dirvožemio vertinimo metodus, nustato dirvožemio fizikines, chemines ir biologines savybe, žinoti tvaraus dirvožemio naudojimo principus, sprendžia agronomijos ir miškininkystės veiklos strateginio pobūdžio uždavinius.

Short course annotation in English (up to 500 characters)

Studying the course “Soil Science” PhD students obtaining knowledge on the consequences of soil in agricultural and forest ecosystems, getting to understand the geological and mineral weathering processes and soil formation principles, adapting and applying soil assessment methods, evaluating soil physical, chemical and biological properties, identifying the principles of sustainable soil principles, implementing soil sustainability in agronomy and forestry technologies.

Relevance of the course

The course helps PhD student to present, analyze, synthesize and critically evaluate new knowledge on soil science, to find out an original scientific solutions, to solve the complex of environmental problems in agronomy and forest practice, to plan fundamental and applied research.

Course aims

The aim of the course is to provide PhD student with knowledge on soil general science research in order to develop technologies to increase or sustain natural and efficient soil fertility, to model the soil ecosystem sustainability and preservation strategies.

Content (topics) and methods

Subject content:

Peculiarities of soil science. Soil science development in the world and in Lithuania. Soil mineral composition, origin, structure and consistence. Peculiarities of rock and mineral formation. Rock weathering and link to plant productivity. Soil parent material, geological classification and impact on weathering and soil formation. Soil formation theory. Soil formation factors and peculiarities for cultivation. Composition of soil phases. Soil granulometry and link to plant productivity. Soil mineral part and chemical composition. Soil organic part and sources from agriculture.

Soil status and properties. Soil colloids and sorption peculiarities. pH value, oxidation and reduction considerations in soil and methods to sustain the regimes. General soil physical properties. Soil moisture and air, warm conditions. Soil fertility status in agriculture and forestry.

Soil structure and morphology. Soil systematics, classification and diagnostic principles. Soil diagnostic materials, properties and horizons. Soil cover. Main patterns of soil distribution (latitude and vertical zonality). The main soil groups in World and distribution properties. Lithuanian and international soil classification principles and soil valuation peculiarities in agriculture and forestry.

Structure of soil cover and contrasting soil distribution. Research on soil cover evaluation. Theoretical and practical aspects of sustainable soil use. **Soil use regulations and directives.** Lithuanian soil quality assessment studies and main results. National soil law. Main principles of Lithuanian soil conservation strategy. Green course initiatives, circular economy action plans and biodiversity strategies associated with soil quality assessment. Objectives of the European Union soil strategy until 2030, and until 2050.

Structure of cumulative score and value of its constituent parts

Doctoral students are scored on the ten-point cumulative assessment and is based on the described criteria for the assessment of the study results: individual activities or practical training - 50 percent of final evaluation; exam - 50 percent of final evaluation. The exam score is given based on student's ability to perform the analyses of individual questions and to discuss. Final examination score to evaluate students' knowledge and abilities are indicated by the examination committee consisting of two course program lecturers and student’s supervisor or consultant.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Buivydaitė V., Motuzas A., Vaičys M. Naujoji Lietuvos dirvožemių klasifikacija. Akademija, 2001.
2.	Mažvila J., Vaičys M., Buivydaitė V. Lietuvos dirvožemių makromorfologinė diagnostika. Akademija (Kėdainių r.), Lietuvos žemdirbystės institutas, 2006.
3.	Vaičys M., Miško augaviečių tipai. Kaunas, Lututė, 2006.
4.	Buivydaitė V., Butkus V., Motuzas A., Pečkytė A., Vaisvalavičius R., Vaišvila Z., Zakarauskaitė D. Geologijos pagrindų ir dirvotyros laboratorinių darbų aprašas. Lietuvos žemės ūkio universitetas, 3-iasis atnaujintas, papildytas. ir pataisytas leidimas, Akademija, 2009.
5.	Eidukevičienė M. Lietuvos gamtinė geografija. Klaipėda, 2009.
6.	Motuzas A., Buivydaitė V., Vaisvalavičius R., Šleinys R. Dirvotyra. Vilnius: Enciklopedija, 2-asis atnaujintas, papildytas ir pataisytas leidimas, 2009.
7.	Volungevičius J., Kavaliauskas P. Lietuvos dirvožemiai. Mokomoji priemonė. Vilniaus universiteto leidykla, 2012.
8.	Volungevičius J., Kavoliutė F., Skorupskas R., Jukna L., Veteikis D. Ekogeografinių kraštovaizdžio tyrimų metodika. Vilniaus universiteto leidykla, 2018.
9.	Staugaitis G, Vaišvila Z.J. Lietuvos dirvožemiai - Dirvožemio agrocheminiai tyrimai. Kaunas, 2019.
10.	Veteikis D., Piškinaitė E. Geografiniai žemėnaudos kaitos tyrimai Lietuvoje: raida, kryptys, perspektyvos. Geologija. Geografija, 5(1), 2019.
11.	Guidance on EU funding opportunities for healthy soils. Directive of the European Parliament and of the Council on Soil Monitoring and Resilience (Soil Monitoring Law). Brussels, 2023.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Schjønning P., Elmholt S., Christensen B.T. Managing soil quality: challenges to modern agriculture. Wallingford UK: CABI publishing, 2004.
2.	Baltrėnas P., Butkus D., Oškinis V., Vasarevičius S., Zigmontienė A. Aplinkos apsauga. Vilnius: Technika, 2008.
3.	Huang P.M., Li Y., Sumner M.E. Handbook of soil sciences: resource management and environmental impacts. CRC Press, 2011.
4.	Mol G., Keesstra S.D. Soil sciences in a changing world. Current opinion in environmental sustainability, 4(5), 473-477, 2012.
5.	Rowell D.L. Soil science: Methods & applications. Routledge, 2014.
6.	Paul E.A. Soil microbiology, ecology and biochemistry. Academic press, 2014.

7.	Keesstra S., Bouma J., Wallinga J., Tittonell P., Smith P., Cerda A. The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals, 2017.
8.	Simonson R.W. Soil classification. In Handbook of Soils and Climate in Agriculture. CRC Press, 2018.
9.	Köninger, J., Panagos, P., Jones, A., Briones, M.J.I. and Orgiazzi, A. In defence of soil biodiversity: Towards an inclusive protection in the European Union. Biological Conservation, 268, 2022.
10.	Wassen, M.J., Schrader, J., Eppinga, M.B., Sardans, J., Berendse, F., Beunen, R., Peñuelas, J. and Van Dijk, J. The EU needs a nutrient directive. Nature Reviews Earth & Environment, 3(5), 2022.
11.	Cornu, S., Keesstra, S., Bispo, A., Fantappie, M., van Egmond, F., Smreczak, B., Wawer, R., Pavlů, L., Sobocká, J., Bakacsi, Z. and Farkas-Iványi, K. National soil data in EU countries, where do we stand? European Journal of Soil Science, 74(4), 2023.

Course program designed by

No.	Name, Surname	Institution	Degree	E-mail address
1.	Jūratė Aleinikovienė	VMU AA	Assoc. Prof. Dr.	jurate.aleinikoviene@vdu.lt
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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8006	7	VMU AA	Agronomy	Agroecosystems and Soil Science

Course title in Lithuanian

Augalų mityba

Course title in English

Plant nutrition	
Study methods	**Volume in ECTS credits**
Lectures	2
Consultations	1
Seminars	-
Individual work	4

Short course annotation in Lithuanian (up to 500 characters)

Dalyko paskirtis – supažindinti doktorantus su augalų mitybos mokslo perspektyvomis, augalų produktyvumo ir derliaus kokybės formavimo ypatumais natūralių ir antropogeninių veiksnių poveikyje, skirtingų tręšimo sistemų dėsningumais ir jų tobulinimo galimybėmis, augalų mitybos lygio bei pasekmių augalui ir aplinkai prognozavimo galimybėmis.

Short course annotation in English (up to 500 characters)

The aim of the subject is to introduce PhD students with perspectives of the plant nutrition science, peculiarities of plant productivity and yield quality formation with regard to natural and anthropogenic factors, regularities of the various fertilization systems and their development options, predictability possibilities of plant nutrition level and impact on plants as well as environment.

Relevance of the course

After the course students will have enough knowledge and skills to plant and perform the fundamental and applicable plant nutrition research, to process the obtained results and with regard to it to frame new knowledge and ideas; with reference to the results of novel carried fundamental and applicable scientific research to analyze the changes in soil properties and plant yield formation, to design and manage plant nutrition processes and to introduce strategic technological solutions for environmental pollution.

Course aims

To develop the system of knowledge, skills, abilities that assure complex assessment and management of plant nutrition processes.

Content (topics) and methods

Topic 1. Development of agrochemistry science (Greek philosophers, ancient Romans, medieval thinkers, development of agrochemistry in 18^{th} –19^{th}, 20^{th} and 21^{st} centuries.
Topic 2. Soil composition, characteristics (agrochemical, physical, biological), regimes (moisture, air, thermal). Soil fertility, its regulation.
Topic 3. Importance of soil fertility for plant nutrition, quality of soil, water and environment.
Topic 4. The regime of organic matter and mineral nutrition elements and transformation in soil. Role of oxygen in the transformation of plant organic matter.
Topic 5. Importance of macro, meso and micro elements in plant nutrition and their forms in plants.
Topic 6. Nitrogen fixation. Biological Nitrogen-Fixing Systems.
Topic 7. Organic and mineral fertilizers and their transformation in soil.
Topic 8. Plant stress. Nutritional regulation of plant productivity under regular and stress conditions.

Topic 9. Plant nutrition and diseases. Topic 10. Spectrometric, morphobiometric and visual detection of plant nutrition. Topic 11. Theoretical, biological and economic reasoning of forms, norms and time selection of fertilizers. Topic 12. Fertilizing systems (extensive, intensive, precision) and their impact on the environment.

Structure of cumulative score and value of its constituent parts

Homework - 40%; Final exam - 60 %.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Fernandez V., Sotiropoulos T., Brown P. Foliar fertilization. Scientific principles. International fertiliezer industry association, 2013. – 144 p.
2.	Lawrence E. Datnoff, Wade H. Elmer, Don M. Huber (edit.) Mineral nutrition and plant disease. American Phytopathological Society, 2007. – 278 p.
3.	Marschner's P. Mineral Nutrition of Higher Plants. Academic Press is an imprint of Elsevier, 2010. – 642 p.
4.	Pessarakli M. Handbook of Plant and Crop Stress (third edition). Taylor and Francis group, London, 2011. – 713 p.
5.	Šlapakauskas V., Kučinskas J. Augalų mityba. Akademija, 2008. – 298 p.
6.	Tripolskaja L., Mašauskas V., Adomaitis T. ir kt. Agroekosistemų komponentų valdymas. Akademija, 2010. –567 p.
7.	Staugaitis G., Vaišvila Z. J. Dirvožemio agrocheminiai tyrimai. 2019. – 112 p.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Dris R. Plant nutrition: growth and diagnosis. Science Publishers, 2002. – 303 p.
2.	Kirkby E. A. Principles of plant nutrition. Dordrecht: Kluwer Academic, 2001. – 849 p.
3.	Šlapakauskas V., Duchovskis P. Augalų produktyvumas: [vadovėlis]. Akademija, 2007. –253 p.
4.	Šlapakauskas V. Augalų ekofiziologija. Mineralinė mityba. Kaunas-Akademija, 2001. – 134 p.
5.	Tripolskaja L. Organinės trąšos ir jų poveikis aplinkai: [monografija]. Akademija, 2005. –214 p.

Course programme designed by

No.	Name, Surname	Institution	Degree	E-mail address
1.	Ernestas Zaleckas	VMU AA	Assoc. Prof. Dr.	ernestas.zaleckas@vdu.lt
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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8008	7	VMU AA	Agronomy	Agroecosystems and Soil Sciences

Course title in Lithuanian

Pasėlių ekologija

Course title in English

Crop ecology

Study methods	Volume in ECTS credits
Lectures	1.5
Consultations	0.2
Seminars	0.3
Individual work	5.0

Short course annotation in Lithuanian (up to 500 characters)

Studijuodami dalyką „Pasėlių ekologija“ doktorantai įgyja žinių apie agrofitocenologijos raidos istorinius matmenis, laukų augalinės dangos ypatumus ir savybes, dirbamų žemių augalų bendrijų (agrofitocenozių) savybes, struktūrą, funkcionavimą, savitvarką, dinamiką, stabilumą, klasifikavimą ir pasiskirstymo dėsningumus, Lietuvos segetalinių ir ruderalinių bendrijų įvairovę.

Short course annotation in English (up to 500 characters)

PhD students studying the course “Crop ecology” acquire knowledge about the historical dimensions of the development of agrophytocenology, peculiarities and properties of the field plant cover, the arable land plant communities (agrophytocenoses) properties, structure, function, dynamics, classification, distribution patterns, the diversity of Lithuanian segetal and ruderal communities.

Relevance of the course

The course helps for PhD students to carry out research of plant communities (agrophytocenoses), acquire practical skills to assess crop communities under the conditions of different farming systems and soil types, to compound field weed cartograms and maps of field plant cover (geobotanical maps).

Course aims

The aim of the course is to provide PhD students with knowledge about crop as part of the ecosystem and landscape, characteristics, structure, functioning, dynamics, classification and distribution patterns of plant communities (agrophytocenoses), human (anthropogenic) influence on the field plant cover, agricultural plant communities diversity.

Content (topics) and methods

Subject content:

Introduction to geobotany. Definition of geobotany. The concept of flora and vegetation. Spontaneous and sinantropic flora. The begining of agriculture. Cultural plants and weeds. Centres of origin of cultural plants. Geographical distribution of plants: ways, aerials and their grouping. Floral elements: geographic, genetic, historical and migratory. Human influence on plant cover or sinantropisation. Classification of sinantropic plants. The ability of plants to adapt to environmental conditions consists of many ecological factors. Concepts of place, habitat, ecotype, biotope. Complexes of ecological conditions: climate, edaphic, orographic and biotic. Definitions of modifications and ecotypes. Plant ecological groups. Plant life forms or bimorphs. Plants indices.

Fundamentals of general phytocenology. Understanding the plant community or phytocenosis. Continuity. Biocenosis, biogeocenosis, ecosystem. Organization of phytocenoses: species composition, populations and cenopopulations, vertical, horizontal and temporal structures, synonyms. Classification of phytocenoses. Concept of syntax. Phytocenosis taxonomic categories. Association – the main unit

of classification of communities. Science about community ecology or synecology. Phytosphere, rhizosphere. Phytocenosis change – succession, climax. Regular patterns of phytocenosis distribution in the land.

Agrophytocenology is a branch of special phytocenology. Definition of agrophytocenology. Historical dimensions of the development of agrophytocenology. The world's most famous agrophytocenologists and their works. Geobotanical concept of the field. Clasifying of field plant cover into crops and unusable plants – segetal and ruderal communities. Agroecosystem. Agrophytocenosis – integral part of the agroecosystem. Species composition of agrofitocenoses. Cenopopulations and their composition. Classification of agrophytocenosis cultural component individuals by age of maturity (ontogenesis). Abundance of species individuals (cenopopulations) and methods for its detection. Population density, its dependence on seed content and other agrotechnical tools. Density of weed populations and factors affecting it. Bank of diasporas. Vertical and horizontal structure of agrophytocenosis. Homogeneity of cenopopulations. Homogeneity indices and detection methods. Temporal structure of agrophytocenosis. Community phenological spectrum, phenological aspects. The concept of sinusia. Influence of ecological factors on agrophytocenosis. Ecological types of crop plants and their indicative value. Plant relationships in agrophytocenosis. Critical period of weed competition for cultural plants. Threshold of weed harmfulness (threshold). Productivity of agrophytocenoses. Functioning, self-regulation, dynamics and stability of agrophytocenosis. Agrophytocenology and agriculture. The importance of agrophytocenology for organic agriculture. Classification of agrophytocenoses: distinctive features of agrophytocenosis, classification systems and methods. Diversity of Lithuanian segetal and ruderal communities. Community indicative properties. Field weed cartograms. Maps of field plant cover (geobotanical maps).

Learning methods:

The lecture, lecture with discussion, report, individual task (analysis of x agrophytocenosis scientific research data), brainstorming.

Structure of cumulative score and value of its constituent parts

A ten-point criterion-based scale and cumulative assessment system is being applied.

Framework of cumulative assessment:

Report – 15 % (6-7 week after report theme performance);
Individual task – 15 % (10 week after individual task performance);
Examination – 70 % (17–20 week).

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Juknys R. Environment research: handbook. Kaunas, Publishing of VMU, 2005. 334 p.
2.	Loomis R. S., Connor D. J. Crop ecology. Productivity and management in the agricultural systems. Cambridge University Press, 1996. 538 p.
3.	Marozas V. Terrestrial ecosystems diversity and protection: handbook. Klaipėda, IDP Solutions, 2008. 112 p.
4.	Natkevičaitė-Ivanauskienė M. Botanical geography and basics of phytocoenology. Vilnius, Publishing of Science, 1983. 280 p.
5.	Pilipavičius V., Pupalienė R., Marcinkevičienė A. Crop communities and their investigations: study book. Klaipėda, IDP Solutions, 2008. 112 p.
6.	Plant communities in changing environment: Book of abstracts. Plant Science and Biodiversity Center SAS, Bratislava, Slovakia, 2022, 110 p. [Electronic resource]. http://euroveg.org/download/evs/30/EVS-2022-Bratislava-Abstracts.pdf

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Balčiauskas L., Butkus R., Dagys M., Gudžinskas Z., Šidagytė E., Vaitonis G., Virbickas T., Žalneravičius E. Invasive species in Lithuania. Vilnius, UAB "Baltijos kopija", 2017, 44 p. file:///C:/Users/105494/Downloads/56795935.pdf

2.	Bučienė A. Ecological relationships of the farming systems: monograph. Klaipėda, Publishing of LKU, 2003. 176 p.
3.	Čiuberkis S., Vilkonis K. K. Weeds in the Lithuanian agroecosystems: monograph. Akademija, Kėdainių distr., 2013. 256 p.
4.	Gudžinskas Z. et al. Invasive organisms of Lithuanian and Latvian border region. Vilnius, Publishing of BMK, 2014. 181 p.
5.	Peart R. M., Shoup D. W. Agricultural systems management: optimizing efficiency and performance. New York, NY, Basel, Marcel Dekker, 2004. 280 p.
6.	Rašomavičius V. Inventory guide of EU importance natural habitats. Vilnius, 2012. 474 p.
7.	Sieglinde S., Pound B., Mass B. Agricultural systems: agroecology and rural innovation for development. Elsevier Academic Press, 2008. 386 p.

Course programme designed by

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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8009	7	VMU AA	Agronomy	Agroecosystems and Soil Sciences

Course title in Lithuanian

ŽEMDIRBYSTĖ

Course title in English

SOIL MANAGEMENT FOR SUSTAINABILITY

Study methods	Volume in ECTS credits
Lectures	2
Consultations	1
Seminars	-
Individual work	4

Short course annotation in Lithuanian (up to 500 characters)

Dalyko paskirtis - suteikti žinių apie tvaraus dirvožemio naudojimo ir su tuo susijusio įvairaus intensyvumo žemės dirbimo poveikį agroekosistemoms, sąsajas su biologiniais, cheminiais bei fizikiniais dirvožemio ekosistemų komponentais, agroekosistemų intensyvinimą ekologinėmis priemonėmis ir adaptaciją klimato kaitai.

Short course annotation in English (up to 500 characters)

This course will provide knowledge of the effects of sustainable soil management and related diverse soil tillage in agroecosystems, interrelations with the biological, chemical, and physical components of soil ecosystems, ecological intensification and adaptation to climate change of the agroecosystems.

Relevance of the course

After the course graduation students will have enough knowledge and abilities to plan and perform the fundamental and applicable research of soil management systems, to process the obtained results and with regard to it to create new knowledge and ideas; with reference to novel research results to analyze the effects of different intensity soil tillage on soil sustainability and environmental quality, considering changing climate conditions; to design strategic technological solutions for agroecosystem sustainability.

Course aims

To develop the system of knowledge, skills, abilities that assure complex assessment and management of soil management systems.

Content (topics) and methods

1. Introduction.
2. Environmental factors for crop growth and their management.
3. Soil degradation and erosion. Soil compaction.
4. Soil quality indicators and their management.
5. Management of crop rotation.
6. Catch cropping and green manure.
7. Straw and other crop residue management.
8. Weed ecology and weed control system.
9. Effect of soil tillage intensity on agroecosystem components.
   - 9.1. The role of soil tillage intensity on soil structure, water capacity and other physical properties.
   - 9.2. Soil tillage and soil microbial community.
   - 9.3. Soil tillage and sustainable nutrient management.

9.4. Implications of soil tillage for crop, weed seeds and weed communities.
9.5. Influence of cultivation practices on arable crop diseases, earthworms and other fauna.
10. Peculiarities of organic, precision and conservation farming systems. Complex assessment and management of soil management systems.
11. Maintenance of ecosystem state, productivity and biodiversity, their integrity over time and in the context of human activity and intensity of use.
12. Sustainability of agroecosystems, ecological intensification and adaptation to climate change.

Structure of cumulative score and value of its constituent parts

Homework - 40%;
Final exam - 60 %.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Fred Magdoff, Harold van Es. Building soils for better crops : ecological management for healthy soils. 2021. – 394 p.
2.	Rattan Lal, B.A. Stewart. Principles of Sustainable Soil Management in Agroecosystems. - CRC Press, 2013. – 568 p.
3.	Rainer Horn, Heiner Fleiner, Stephan Peth, Xinhau Peng (Editor). Soil management for Sustainability. 2006. -497 p.
4.	Karl Heinrich Hartge, Rainer Horn. Essential Soil Physics: An introduction to soil processes, functions, structure and mechanics. Schweizerbart Science Publishers 2016. - 389 p.
5.	C.J. Baker, K.E. Saxton, W.R. Ritchie, W.C.T. Chamen, D.C. Reicosky, M.F.S. Ribeiro,
6.	S.E. Justice, P.R. Hobs. No-tillage seeding in conservation agriculture. CAB International and FAO, 2007. - 326 p.
7.	Adel El Titi (Editor). Soil tillage in Agroecosystems. 2003. -367 p.
8.	Håkansson I. Machinery-induced compaction of arable soils. Inicidence – consequences – counter-measures. Swedish University of Agricultural Sciences. 2005. -153 p.
9.	Maren Oelbermann. Sustainable Agroecosystems in Climate Change Mitigation. - Wageningen Academic Publishers, 2014. – 164 p.
10.	Patrick J. Bohlen, Gar House. Sustainable Agroecosystem Management: Integrating Ecology, Economics, and Society. - CRC Press, 2009. – 328 p.
11.	Sven E. Jørgensen, Liu Xu, Robert Costanza. Handbook of Ecological Indicators for Assessment of Ecosystem Health. - CRC Press, 2010. – 498 p.
12.	Managing cover crops profitably. Editor Andy Clark. - Sustainable Agriculture Network, 2007. – 244 p.
13.	C.F. Jordan. An Ecosystem Approach to Sustainable Agriculture: Energy Use Efficiency in the American South. 2013. -247 p. DOI 10.1007/978-94-007-6790-4
14.	Marek K. Jarecki & Rattan Lal (2003). Crop Management for Soil Carbon Sequestration, Critical Reviews in Plant Sciences, 22:6, 471-502, DOI: 10.1080/713608318

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Bučienė A. Žemdirbystės sistemų ekologiniai ryšiai. 2003. -180 p.
2.	Gerosios žemės ūkio praktikos kodeksas kurio taikymas mažintų neigiamą žemės ūkio poveikį dirvožemiui, vandeniui, orui ir klimatui. (V.Feiza ir kt.) Vilnius, 2019. – 205 p. (GZUP Kodeksas taisytas po AplinkosM- birzelis.pdf (lrv.lt)).
3.	Špokienė N., Povilionienė E. Piktžolės. Kaunas, 2003, 200 p.
4.	Michael A. Fullen, John A. Catt. Soil management: problems and solutions. 2004. -269 p.
5.	Benjaminas Kiburys. Dirvožemio mechaninė erozija. V.: Mokslas. 1989. 175 p.
6.	Jankauskas B. (1990). Dirvų apsauga nuo erozijos. V., 85 p.
7.	Soane B.D., C. van Onwerkerk (Editors). Soil Compaction in Crop Production. Elsevier,

	1994. - 662 p.
8.	Soil biological fertility. Edited by Lynette Abbott, Daniel Murphy. Springer, 2007. -264 p.
9.	Lampkin N. (2002) Organic farming. Old Pond Publishing, 748 p.
10.	Noureddine Benkeblia. Agroecology, Ecosystems, and Sustainability. - CRC Press, 2014. – 393 p.
11.	John M. Kimble, Charles W. Rice, Debbie Reed, Sian Mooney, Ronald F. Follett, Rattan Lal. Soil Carbon Management: Economic, Environmental and Societal Benefits. - CRC Press, 2007. – 280 p.

Course programme designed by

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Approval at the meeting of the PhD programme committee on October 16, 2024, by Resolution No. 218.

Course description valid until October 16, 2028.

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
AGR8014	7	VMU AA	Agronomy	Plant biology and food sciences

Course title in Lithuanian

Sodo ir daržo augalų selekcija ir sėklininkystė

Course title in English

Breeding and Seed Growing of Horticultural Plants

Study methods	Volume in ECTS credits
Lectures	1.65
Consultations	0.07
Exam	0.07
Individual work	5.21

Short course annotation in Lithuanian (up to 500 characters)

Kursas skirtas doktorantams Gautų žinių pagrindu studentai suvoks kryžmadulkių, savidulkių ir vegetatyviniu būdu dauginamų augalų selekcijos ir sėklininkystės ypatumus. Sugebės parinkti pradinę medžiagą selekciniam darbui, sudaryti kryžminimo schemas, įvertinti hibridinius palikuonis įvairiose selekcijos grandyse, nustatyti strategiją, sudaryti selekcines programas ir kurti naujas veisles. Žinos heterozinių hibridų, kryžmadulkių ir savidulkių augalų sėklininkystės sistemas bei veislių identifikavimo metodus, susipažins su augalų veislių teisine apsauga Lietuvoje, ES valstybėse ir pasaulyje.

Short course annotation in English (up to 500 characters)

The Course is designed for PhD Students. The students will understand the peculiarities of breeding of cross-, self-pollinating, and vegetative propagating plants, and know the seed production system. Will be able to select the material for the breeding, to define the breeding strategy, and make programs to create new varieties. Will know the systems for creating heterozygous hybrids, methods of identification of varieties, will get acquainted with the legal protection of plant varieties in Lithuania, EU countries, and the world.

Relevance of the course

After the course, students will have enough knowledge and skills to analyze and address the most relevant issues of plant breeding and seed production.

Course aims

The new systematic knowledge of plant genetics and breeding that can be applied interpreting the results of agronomic and biological research

Content (topics) and methods

Lectures:

1. Historical development of plant breeding in the world and Lithuania.
2. Genetic Basics of Plant Breeding.
3. Physiological and morphological basics of plant breeding.
4. Starting material for selection.
5. Plant selection methods and their use in practical selection.
6. The main directions of plant breeding.
7. Organization of selection work.
8. Evaluation of breeding material.
9. Registration, state investigation, and protection of varieties.
10. Seed production.

***Methods of study*:** lectures, consultations, self-study using additional material. In the absence of a minimum number of doctoral students for lectures individual consultations will be provided.

Structure of cumulative score and value of its constituent parts

1. The mastery of the knowledge. 2. Ability to use the knowledge supporting multiplication techniques for different types of plants 4. Identification of practical problems of breeding and their solutions.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Singh P.K., Dasgupta S.K., S.K. Tripathi. Hybrid Vegetable Development. Food Products Press.2004, 441 p.
2.	Hayward M.D., Bosemark M.O., Ramogosa I. Plant breeding principles and prospects. Champan Hall-London-Weinheim-Mew York-Tokyo-Melbourne-Madras. 1993.-550.
3.	Rančelis V. Genetika V.2000.-662
4.	Moore J.N., Janic J. Methods in fruit breeding.- West Lafayete (Indiana) Purdue University Press, 1983.-419p
5.	P. Lower. Seeds. The Definitive Guide to Growing, History, and Lore. Timber Press. Portland. Cambrige. 2005. 229 p.
6.	G. Acquaah. Principles of Plant Genetics and Breeding. Blackwell Publishing. 2007. 569 p.
7.	Jameel M. Al-Khayri, S. Mohan Jain, Dennis V. Johnson (ed.). Advances in Plant Breeding Strategies: Vegetable Crops. Springer Cham. 2021. doi.org/10.1007/978-3-030-66961-4
8.	Hari Har Ram. Vegetable Breeding: Principle and Practices. 2019. Kalyani Publishers.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication.
1.	Nguyen H.T., Blum A. Physiology and biotechnology integration for plant breeding. Marsel Dekker Inc.2004, 626 p.
2.	Bowling B.L. The Berry grower's companion. Timber Press. 2000. 280 p.
3.	Балашова Н.Н. Селекция и семеноводство овощных и бобовых культур. Кишинев-1989.-279 с.
4.	Journal of Plant Breeding and Genetics. eSci Journals Publishing
5.	Theoretical and Applied Genetics. Springer
6.	Euphytica. Springer
7.	Acta Horticulturae. ISHS

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