Detailed Course Descriptions of Plant Science Subjects Offered by the Doctoral School of Agricultural and Food Sciences

Course title / Neptun code: **MATER073N Statistical Methods**	Number of credits: 10
Course coordinator (name, position, academic degree): Dr. Márta Ladányi, DSc	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): Dr. Anna László, PhD	
Course type: compulsory/elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: 26 contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): theory, case-study analyses, project-based learning	
Requirements for successful completion: project work submission	
Assessment methods applied for evaluating learning outcomes: commented evaluation of the project work	
Recommended semester: fall (first or second)	
Prerequisites (if any): *master level statistical knowledge*	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
Based on the knowledge students have acquired in standard Biometrics and Statistics courses at the master's level, selected chapters of advanced statistics will be discussed using complex applications. We work in a computer-based environment. Statistical methods are presented in a practical manner, with numerous agricultural applications tailored specifically to the needs of PhD students, while also addressing special data management issues and proper documentation practices. Students who lack a master's-level statistical background and need to prepare for this course can register for the Biometrics course (MATER074N) to bridge the knowledge gap. They can enrol in both the "Biometrics" and "Statistical Methods" courses in the same fall semester. In this case, the courses will be taught sequentially in intensive blocks, starting with "Biometrics" and followed by "Statistical Methods".	
Course Topics / Semester Schedule: Statistical hypothesis testing, revision: data types, outliers, missing data, Type I and Type II errors, significance level, normality tests, one- and two-sample parametric tests; one-way ANOVA; skewness and kurtosis tests, data transformation, sampling, sample size and power calculation Experimental design, one- and two-way ANOVA, ANCOVA models, GLM, GLMM, repeated measures ANOVA, post hoc tests, graphical representation Linear and nonlinear uni- and multivariate regression models, regression diagnostics, confidence intervals and bands, collinearity, PCA regression, quantile regression, write-up; Crosstabulation, ratio tests	

List of the 2–5 Most Important Required Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Special handouts are available during the course.
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Tabachnick, B. G., Fidell, L. S. (2019, e-version 2022). Using Multivariate Statistics (7th ed.). Pearson. ISBN 9780134790541, 0134790545, e-version: ISBN-13: 9780137526543 Andy F. (2024). Discovering Statistics Using IBM SPSS Statistics (6th ed.). SAGE Publications. ISBN 1529668719, 9781529668711
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility
a) Knowledge Students acquire statistical methods in an SPSS environment based on real-world research, directly supporting the analyses required for their experimental or observational research, as well as their literature review work. **b) Skills** Students will be able to analyse data arising from biological-chemical research in a statistically and ethically sound manner, as well as interpret, visually present, and communicate results to a scientific standard. **c) Attitude** Students develop the scientific rigor necessary for performing high-quality statistical analyses and for critically and insightfully reading statistical analyses in scientific journals. **d) Autonomy and Responsibility** Students learn to conduct data analysis independently, responsibly, honestly, and precisely.

Course Description

Course title / Neptun code: Biological Pest Control - NVVED068N	Number of credits: 8
Course coordinator (name, position, academic degree): Turóczi György József, associate professor, PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): -	
Course type: compulsory/elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: .....28.... contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): lecture – summary of basic knowledge related to the subject – individual case study – review of literature	
Requirements for successful completion: presentation of an individual case study	
Assessment methods applied for evaluating learning outcomes: joint evaluation of case studies	
Recommended semester: variable	
Prerequisites (if any): -	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
Basic knowledge of specific sub-areas of biological plant protection, learning about the main research directions, understanding the possibilities and limitations of practical application	
Course Topics / Semester Schedule: Microbial antagonism; Insect pathogenic organisms; Parasitoids and predators; Possibilities of biological control against weeds; Other means of biological control; Regulation and practical implementation of biological control.	
List of the 2–5 Most Important Required Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.	

- N. Birch, T. Glare (eds) 2020. Biopesticides for sustainable agriculture. Burleigh Dodds Science Publishing, London - Boys, E. (ed): Encyclopaedia of pests and natural enemies in field crops, Agriculture and Horticulture Development Board, 2016 - Detailed text of the presentations (Turóczi György)
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
https://www.ifoam.bio/resource-library http://www.iobc-wprs.org/ https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN https://www.koppert.com/ https://www.biobestgroup.com/ https://www.efsa.europa.eu/
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility
Students will gain in-depth knowledge of each area of biological plant protection. They will become able to deterrmine and develop new research tasks and approach the new challenges of plant protection with an environmentally conscious approach.

Course Description

Course title/Neptun code: Biotic Stress	**Credit:** 8
Course coordinator (name, position, academic degree): Dr. Balázs Barna, Honorary Professor	
Lecturer(s) involved in teaching the course, if any (name, position, academic degree):	
Course classification: compulsory / elective	
Type of class: lecture/seminar/practical/consultation and total number of contact hours in the semester: 52 contact hours	
Methods and specific tools/characteristics used for knowledge transfer, e.g. case presentations, case study analysis, project work, other: Project work, case studies	
Mode of assessment (exam / practical grade / other): exam	
Assessment method(s) used for knowledge evaluation: in-class assignments	
Curricular placement (semester): 2	
Prerequisites (if any): NO	
Course description: concise but informative description of the course objectives and the knowledge to be acquired	
Course objective: To familiarize students with the types of biotic stress affecting plants, their development, and the molecular, physiological and ecological background of plant–pathogen and plant–pest interactions. **Knowledge to be acquired:** Up-to-date knowledge of pathogens and pests causing biotic stress, plant stress responses and defense mechanisms, as well as the effects of biotic stress on plant growth, yield formation and plant health.	
• **The concept and significance of biotic stress** – types of biotic stress affecting plants, their development and agricultural significance. • **Plant–pathogen interactions** – stress processes induced by pathogenic fungi, bacteria, viruses and other pathogens. • **Plant–pest interactions** – stress caused by insects, mites and other pests, as well as plant responses. • **Innate plant defense mechanisms** – physical, chemical and molecular defense processes. • **Plant immunity and signaling** – pathogen recognition, signaling molecules, hormonal regulation and activation of defense genes.	

• **The relationship between biotic and oxidative stress** – formation of reactive oxygen species, antioxidant systems and cellular responses.

• **Effects of biotic stress on plant physiological processes** – photosynthesis, respiration, water relations, growth and yield formation.

• **The plant microbiome and biotic stress** – the role of beneficial microorganisms in plant health and the development of stress tolerance.

• **Biological plant protection and induced resistance** – microbial agents, biopreparations and activation of plant defense mechanisms.

• **Interactions between biotic and abiotic stresses** – combined stress effects and complex plant stress responses.

• **Modern methods for studying biotic stress** – phenotyping, physiological, microbiological, molecular and omics approaches.

• **Current issues and future directions in biotic stress research** – climate change, the emergence of new pathogens and pests, and opportunities for sustainable plant protection.

List of the 2–5 most important compulsory literature sources (lecture notes, textbooks), with bibliographic details (author, title, publication details, pages, ISBN):

• **Agrios, G. N. (2024):** ***Agrios' Plant Pathology. 6th Edition. Academic Press, Elsevier.***
Particularly the chapters dealing with host–pathogen interactions, plant immunity, defense mechanisms, disease development and epidemiology. The 6th edition also covers current knowledge of plant immunity and defense mechanisms.

• **Sessa, G. (ed.) (2012):** ***Molecular Plant Immunity. Wiley-Blackwell.***
The molecular basis of plant immunity, pathogen recognition, signaling processes, resistance genes, hormonal regulation and current approaches to plant–pathogen interactions.

• **Rout, G. R. – Das, A. B. (eds.) (2013):** ***Molecular Stress Physiology of Plants. Springer.***
The molecular and physiological basis of plant stress physiology, including plant responses to biotic stress and stress tolerance.

List of the 2–5 most important recommended literature sources (lecture notes, textbooks), with bibliographic details (author, title, publication details, pages, ISBN):

• **Oliver, R. P. (ed.) (2024):** ***Agrios' Plant Pathology. 6th Edition. Academic Press, Elsevier.***
Comprehensive coverage of plant diseases, pathogenicity, plant immunity, defense mechanisms, and diseases caused by fungi, oomycetes, bacteria, viruses and nematodes.

• **Sessa, G. (ed.) (2012):** ***Molecular Plant Immunity. Wiley-Blackwell.***
The molecular basis of plant immunity, pathogen recognition and plant defense responses.

• **Rout, G. R. – Das, A. B. (eds.) (2013):** ***Molecular Stress Physiology of Plants. Springer.***
The molecular and physiological basis of plant stress physiology, with particular emphasis on stress responses.

Which professional competencies, competency elements and skills does the course typically and substantially contribute to developing (knowledge, skills, attitude, autonomy and responsibility):

Knowledge:
The student acquires in-depth and up-to-date knowledge of biotic stress, plant–pathogen and plant–pest interactions, plant immunity, stress physiology and defense mechanisms, and becomes familiar with modern research methods for studying biotic stress.

Skills:
The student becomes capable of independently identifying and analyzing scientific problems related to biotic stress, critically evaluating relevant literature, interpreting research results, and appropriately selecting and applying modern research methods.

Attitude:
The student is open to new scientific findings and research methods and strives for critical and systems-oriented thinking, evidence-based conclusions, and consideration of sustainable plant protection principles.

Autonomy and responsibility:
The student is able to independently design and scientifically substantiate research tasks related to biotic stress, base decisions on scientific evidence, critically evaluate results, and take responsibility for their professional interpretation and presentation.

Course Description

Course: Communication and Presentation of Experimental Results, Dissertation Preparation with Special Emphasis on the Use of AI

Course Code: GENBT064N

Credits: 10

Level: Doctoral (PhD)

Course Type: Core Course

Doctoral School: Hungarian University of Agriculture and Life Sciences (MATE), Doctoral School of Agricultural and Food Sciences

Course Coordinator: Dr. Zoltán Pék

The course aims to provide doctoral students with advanced knowledge and practical skills in scientific communication, academic publishing, and dissertation preparation. Special emphasis is placed on the dissemination of research results, the preparation of scientific manuscripts and doctoral dissertations, and the responsible and ethical use of artificial intelligence (AI) throughout the research and writing process.

The course supports the development of independent researchers capable of producing high-quality scientific publications and effectively communicating research outcomes to the scientific community and other stakeholders. Particular attention is given to publication strategies in agricultural, biological, food, and plant sciences.

Learning Outcomes

Upon successful completion of the course, students will be able to:

- critically evaluate and synthesize scientific literature;
- conduct efficient literature searches using national and international scientific databases;
- design publication strategies appropriate to their research field;
- prepare scientific manuscripts according to international publishing standards;
- select suitable journals and avoid predatory publishers;
- apply reference management tools and citation standards;
- communicate research findings through oral presentations, posters, and visual abstracts;
- prepare doctoral dissertations and thesis booklets;
- use AI-based tools responsibly and transparently in scientific research and academic writing;
- comply with principles of research integrity, publication ethics, and good scientific practice.

Course Content

1. Scientific Publishing in Doctoral Education

- Publication requirements of doctoral studies

- Research groups and scientific collaboration
- Research planning and academic career development

2. Literature Review and Scientific Information Retrieval

- Principles of systematic literature review
- National scientific databases (MTMT, MATARKA, EPA)
- International databases (Web of Science, Scopus, CAB Abstracts, AGRIS)
- Academic repositories and open-access resources
- Keyword selection and search strategies

3. Scientific Writing

- Structure of scientific papers (IMRaD model)
- Writing titles, abstracts, and keywords
- Introduction and literature review
- Materials and Methods
- Results and Discussion
- Conclusions and recommendations

4. Journal Selection and Publication Strategy

- Criteria for journal selection
- Impact factor and journal ranking systems
- Quartile classifications (Q1-Q4)
- Open-access publishing
- Peer-review process
- Predatory journals and publishers

5. Research Ethics and Scientific Integrity

- Research ethics and responsible conduct of research
- Authorship and contributorship
- Plagiarism and self-plagiarism
- Data management and reproducibility
- Ethical aspects of AI-assisted academic writing

6. Reference Management

- Zotero
- Mendeley
- EndNote
- Citation styles and bibliography generation

7. Artificial Intelligence in Scientific Research and Writing

- AI-assisted literature analysis
- AI-supported academic writing
- Language and style improvement tools
- AI-based research assistants
- Limitations, risks, transparency, and validation of AI-generated content

8. Scientific Communication and Presentation Skills

- Oral presentations and conference lectures
- Poster design and presentation
- Data visualization
- Scientific graphics and illustrations
- Visual abstracts and science communication

9. Dissertation Preparation

- Structure of a doctoral dissertation
- Preparation of thesis summaries
- Publication-based dissertations
- Preparation for the doctoral defence

Teaching Methods

- Interactive lectures
- Seminar discussions
- Case-study analysis
- Practical workshops
- Demonstrations of AI-supported research tools
- Student presentations
- Peer review and collaborative learning

Assessment

- Active participation in lectures and seminars
- Literature review assignment
- Critical evaluation of a scientific paper
- Practical application of AI-supported academic tools
- Félévzáró értékelés:

Final Assessment

Preparation of a publishable scientific manuscript or a dissertation chapter

Oral presentation and defence of the submitted work

Recommended Literature

1. Day, R.A. & Gastel, B. How to Write and Publish a Scientific Paper.
2. Hofmann, A.H. Scientific Writing and Communication: Papers, Proposals, and Presentations.
3. Alley, M. The Craft of Scientific Presentations.
4. Glasman-Deal, H. Science Research Writing for Non-Native Speakers of English.
5. Guidelines and recommendations of the Hungarian Academy of Sciences concerning scientific publishing and research integrity.
6. Documentation and user guides of Web of Science, Scopus, MTMT, Zotero, Mendeley, EndNote, and AI-assisted academic writing platforms discussed during the course.

Course Description

Course title / Neptun code: Weed biology and ecology	Number of credits: 6
Course coordinator (name, position, academic degree): Dr. Gabriella Kazinczi DSc, university professor	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): -	
Course type: compulsory/elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: .36. contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): Knowledge is transferred through professional consultations.	
Requirements for successful completion: It is necessary to make a 25-35 page essay (description of a freely chosen weed species, its biology, distribution, harmful effect and options for control).	
Assessment methods applied for evaluating learning outcomes: oral exam on the knowledge areas specified in the topic and evaluation of the written assay on a five-point scale (1-5).	
Recommended semester: it can be chosen in any semester	
Prerequisites (if any): -	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
The aim of the subject is to provide biological and ecological background knowledge of weeds, that serves as a theorethical basis for the planning and implementation of effective weed management strategies.	
Course Topics / Semester Schedule: Basic principles of weed biology, harmful effects Most important weed species in Hungary and worldwide Weed and weed seed knowledge Life form of weed species Regeneration biology of weeds (annuals, perennials) Interference among higher plants (competition, allelopathy) Weed survey methods Herbicide resistance Invasive weed species Biological principles of integrated weed management	
List of the 2–5 Most Important Required Literature	

(textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Zimdahl, R.L. (2004): Weed-Crop Competition. A review. Blackwell Publishing ISBN: 0-8138-0279-2 Baskin, J.M., Baskin C.C. (1998): Seeds. Ecology, Biogeography and Evolution of Seed Dormancy and Germination. Academic Press, San Diego ISBN:0-12-080260-0 Holm, L.G., Plucknett, D.L., Pancho, J.V., Herberger, J. P. (1991): The World's Worst Weeds. Distribution and Ecology. Krieger Publishing Company, Malabar, Florida ISBN: 978-0-8248-0295-0
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN. Harper, J.L. (1977): Population Biology of Plants. Academic Press, London ISBN: 0123258502, 9780123258502 Rao, V.S. (2009): Principles of Weed Science. CRC Press, Boca Raton, London, New York, ISBN: 1-57808-069-X Hatcher P., Froud-Williams, R.J (eds) (2017): Weed Researc. Wiley, Chichester, ISBN: 9781119380603
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility

Course Description

Course title/Neptun code: General and Plant Pathological Mycology	**Credit:** 8
Course coordinator (name, position, academic degree): Dr. Katalin Körösi, Associate Professor	
Lecturer(s) involved in teaching the course, if any (name, position, academic degree):	
Course classification: compulsory / elective	
Type of class: lecture/seminar/practical/consultation and total number of contact hours in the semester: 52 contact hours	
Methods and specific tools/characteristics used for knowledge transfer, e.g. case presentations, case study analysis, project work, other: Project work, case presentations	
Mode of assessment (exam / practical grade / other): exam	
Assessment method(s) used for knowledge evaluation: in-class assignments	
Curricular placement (semester): 2	
Prerequisites (if any):	
Course description: concise but informative description of the course objectives and the knowledge to be acquired	
Course objective: To familiarize students with fundamental and up-to-date knowledge in plant pathological mycology, including the taxonomy, biology and lifestyles of plant-pathogenic fungi and fungus-like organisms, as well as host–pathogen interactions. **Knowledge to be acquired:** The morphology, taxonomy, reproduction and infection processes of plant-pathogenic fungi and fungus-like organisms; the symptoms, epidemiology and diagnosis of diseases caused by major plant-pathogenic groups. The course also covers modern mycological and molecular diagnostic methods, as well as contemporary approaches to the identification and classification of pathogens.	
• **Fundamentals of plant pathological mycology** – the significance, concept and role of plant-pathogenic fungi and fungus-like organisms in the development of plant diseases. • **Morphology and biology of fungi and fungus-like organisms** – vegetative and reproductive structures, growth, reproduction and life cycles. • **Taxonomy and phylogeny of plant-pathogenic fungi** – major taxonomic groups and modern molecular approaches to classification.	

• **Fundamentals of plant–pathogen interactions** – infection, colonization, pathogenicity, virulence and host susceptibility.

• **Infection processes and pathogen dissemination** – inoculum production, infection, reproduction, modes of dissemination and the role of environmental factors.

• **Major groups of plant-pathogenic fungi I** – Ascomycota and related pathogens, major plant diseases and their causal agents.

• **Major groups of plant-pathogenic fungi II** – Basidiomycota, rust fungi, smut fungi and other important pathogens.

• **Oomycota and other fungus-like plant pathogens** – major species, their lifestyles and the diseases they cause.

• **Plant pathological symptomatology and differential diagnosis** – characteristic symptoms of fungal diseases, their differentiation and diagnostic approaches.

• **Plant pathological mycological diagnostics** – classical mycological, culturing, serological and molecular diagnostic methods.

• **Ecology and epidemiology of plant-pathogenic fungi** – survival, inoculum sources, infection cycles and disease development.

• **Modern molecular and genomic approaches in mycology** – DNA-based identification, barcoding, phylogenetic analyses and genomic methods.

• **Current research directions in plant pathological mycology** – emerging pathogens, host–pathogen interactions, changes in pathogen populations and the effects of climate change.

List of the 2–5 most important compulsory literature sources (lecture notes, textbooks), with bibliographic details (author, title, publication details, pages, ISBN):

• **Agrios, G. N. (2024):** ***Agrios' Plant Pathology. 6th Edition. Academic Press, Elsevier.***
A comprehensive plant pathology textbook covering plant disease development, pathogen biology, host–pathogen interactions, diagnostics and disease management.

• **Webster, J. – Weber, R. (2007):** ***Introduction to Fungi. 3rd Edition. Cambridge University Press.***
A modern overview of fungal morphology, biology, reproduction, ecology and taxonomy.

• **Dean, R. – Van Kan, J. A. L. – Pretorius, Z. A. – Hammond-Kosack, K. E. – Di Pietro, A. – Spanu, P. D. – Rudd, J. J. – Dickman, M. – Kahmann, R. – Ellis, J. –**

Foster, G. D. (2012): ***The Top 10 fungal pathogens in molecular plant pathology. Molecular Plant Pathology, 13(4), 414–430.***

List of the 2–5 most important recommended literature sources (lecture notes, textbooks), with bibliographic details (author, title, publication details, pages, ISBN):

- **Kirk, P. M. – Cannon, P. F. – Minter, D. W. – Stalpers, J. A. (eds.):** ***Dictionary of the Fungi.***

For studying fungal taxonomy, nomenclature and taxonomic background.

- **Alexopoulos, C. J. – Mims, C. W. – Blackwell, M. (1996):** ***Introductory Mycology. 4th Edition. Wiley.***

A classic, comprehensive reference on fungal biology and taxonomy.

- **Agrios, G. N.:** ***Plant Pathology. Earlier editions.***

Supplementary literature for deeper study of classical plant pathology, symptomatology, epidemiology and plant protection aspects.

- **Mycological Handbook:**

For the practical study of the morphology, taxonomy, lifestyle and identification of plant-pathogenic fungi and fungus-like organisms.

- **Samson, R. A. – Hoekstra, E. S. – Frisvad, J. C. – Filtenborg, O. (2004):** ***Introduction to Food- and Airborne Fungi. 7th Edition. Centraalbureau voor Schimmelcultures.***

Which professional competencies, competency elements and skills does the course typically and substantially contribute to developing (knowledge, skills, attitude, autonomy and responsibility):

Knowledge:

The student acquires comprehensive and up-to-date knowledge of the foundations of plant pathological mycology, the taxonomy, morphology, lifestyles and reproduction of plant-pathogenic fungi and fungus-like organisms, as well as the fundamental processes underlying host–pathogen interactions and plant disease development.

Skills:

The student becomes capable of recognizing plant-pathogenic fungi and the diseases they cause and of evaluating them through differential diagnosis, linking symptoms to pathogen characteristics, and independently processing and critically evaluating plant pathology and mycological literature.

Attitude:

The student is open to new scientific findings, diagnostic methods and molecular approaches in mycology and plant pathology. The student strives for precise, critical and

evidence-based professional thinking and for a complex assessment of plant health problems.

Autonomy and responsibility:
The student is able to independently identify professional problems, select appropriate plant pathological and mycological examination methods, critically evaluate results and present them in a scientifically rigorous manner, while taking responsibility for the soundness of professional conclusions.

Course Description

Course title / Neptun code: **Classical and Detailed Plant Breeding** **GENBT069N**	Number of credits: 8
Course coordinator (name, position, academic degree): **Dr. habil. Hajós Lászlóné**, r. Associate professor, PhD, CSc.	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): **Dr. habil. Hajós Lászlóné**, r. Associate Professor PhD **Dr. Polgári Dávid Assistant professor, Ph.D**	
Course type: **compulsory**/elective	
Type of class: **lecture**/seminar / practical / consultation, and total number of contact hours in the semester: **16 contact hours**	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): **informative presentations**	
Requirements for successful completion: **Attendance at all lectures is expected**. *Attendance and participation*: **10 pts** *Discussion of Journal Article*: **20 pts** *Oral exam: presentation (15 min)* on the topic of the PhD thesis emphasizing its significance in plant breeding (**70 pts**)	
Assessment methods applied for evaluating learning outcomes: The assessment has two steps. *Step 1*: **in order to get the lecturer's signature students will also be required to present and discuss a journal article in front of the class during the lectures before the end of the semester**. *Step 2:* **During the exam students have to present a ppt about a given topic.** A student, who does not gain at least 52 points by the first exam, can repeat the exam twice. The five grades are 1,2,3,4,5 based on the points gained out of the total 100 points as listed in the table bellow:	

5 (excellent)	86-100 pts
4 (good)	76-85 pts
3 (satisfactory)	61-75 pts
2 (pass)	53-60 pts

1 (fail)	52 pts and below

Recommended semester: **Fall**

Prerequisites (if any): **understanding of basic classical genetics or permission of the instructor**

Course Description

The goal of this course is to offer insights into the technical and industrial aspects of plant breeding, ranging from classical genetic improvement based upon phenotypic selection up to advanced molecular crop breeding based upon genetic or genomic information. In parallel, the student receives an overview of the principal breeding methodologies and strategies that are currently applied in some major agronomic crop species and additionally gets introduced into innovative techniques for the genetic improvement of plants.

Course Topics / Semester Schedule:

1. Role and evolution of plant breeding. Breeding objectives.
2. Domestication and centers of genetic diversity.
3. Genetic resources. Pre-breeding. Gene banks.
4. Modes of reproduction. Fertility regulation mechanisms.
5. Sources of variation in phenotype.
6. Creation of genetic variability by traditional and new methods.
7. Development of mutant varieties through irradiation, chemical mutagenes and space breeding. Tilling.
8. Line, hybrid and DH cultivars in self-, cross-pollinating and asexually propagating crops.
9. Transgenezis, cisgenezis, genome editing.
10. Breeding for improved disease resistance.
11. Breeding for environmental stresses.
12. Breeding for high yield. G x E x M interactions.
13. Cultivar registration, maintenance, increase and release.
14. Breeding of selected crops.

This is a tentative course outline and may be subject to change.

List of the 2–5 Most Important Required Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Required Literature **George Acquaah** (2012): **Principles of Plant Genetics and Breeding**. 2nd Edition. ISBN 978-1-4051-3646-4. Part I: sections 3, 5, 6, 7 and 8. Part II: breeding wheat or corn or rice or sorghum or cotton. **Pdf versions of the lectures and other supplement materials**
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Recommended Literature **Walter Suza and Kendall Lamkey** (eds) 2023: **Crop Improvement**. Iowa State University Digital Press, DOI: https://doi.org/10.31274/isudp.2023.138 Chapters 1, 2, 3, 5, 6, 7 and 16.
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility
After successful completion of this course students will have an overview about the traditional and molecular/genomic techniques applied in plant breeding. They will be able to speak and understand the language of plant breeding, and to discuss it with experts or with laymen.

Course Description

Course title / Neptun code: **Practical Plant Breeding GENBT070N, SDINTD8_022**	Number of credits: 8
Course coordinator (name, position, academic degree): **Dr. habil. Hajós Lászlóné** r. Associate Professor, PhD, CSc	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): **Dr. Polgári Dávid Assistant Professor, PhD**	
Course type: compulsory/elective **elective**	
Type of class: **lecture**/seminar / **practical** / consultation, and total number of contact hours in the semester: ...16..... contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): **informative presentations**	
Requirements for successful completion: **In order to get the lecturer's signature students have to attendance at all lectures, and have to complete the practical works. For those who couldn't take part in each lecture or in the practical sessions, an additional task will be given to fulfill.** *Oral exam: presentation (10 min)* on the topic of the PhD thesis given by the lecturer (**40 pts**).	
Assessment methods applied for evaluating learning outcomes: *Attendance at lectures 20 pts* *Practical work 40 pts* *Exam 40 pts* **Total points = 100 pts** 5 (excellent) 86-100 scores 4 (good) 76-85 scores 3 (satisfactory) 61-75 scores 2 (pass) 51-60 scores 1 (fail) 50 scores and below	
Recommended semester**:**	
Prerequisites (if any): **A good understanding of the concepts of genetics, and reproductive biology are assumed or the permission of the course leader.**	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	

This course is designed for students who want to understand both the theory and practice of plant breeding. Students will acquire insights into the conventional and advanced methods by which crops are improved, their practical implementation, and how this is influenced and determined by crop reproductive biology and trait genetics. The course combines lectures and laboratory exercises during a study visit to a plant breeding research institute.

Topics of the lectures/ Semester Schedule:;

1. The milestones in plant breeding. What is a cultivar? Goals and phases of plant breeding.
2. Sexual and asexual propagation. Self- and cross pollination sytems; male sterility, self incompatibility. Artificial cross-pollination. Steps of artificial selfing and crossing.
3. Classification of germplasms. Preservation of genetic resources; *ex situ:* seed, *in vitro*, cryopreservation. DNA conservation. *In situ* conservation.
4. Aimes and methods of pre-breeding, MABC.
5. Qualitative and quantitative variation in plants.
6. Genetic variability. Sexual gene transfer within and between plant species; types of artificial crossing; somatic cell hybridization, genetic transformation.
7. Mutation induction; types of mutagenes, optimal dose/concentration, selection of mutants by traditional and advanced methods.
8. Classification of polyploids. Artificial induction. Mitotic and meiotic polyploidization. *In vitro, ex vitro and in vivo* induction. Treated materials, treatments, optimal concentration. Detection of polyploids.
9. Haploids. *In vitro* and *in vivo* haploids. Detection of putative haploids by cytological methods, SSR or SNP markers and morphological traits.
10. Line, hybrid and DH cultivars. Transgenezis, cisgenezis and gene editing.
11. Mechanisms of disease resistance. Plant pathogen interactions. Traditional and advanced methods in resistance breeding. Gene pyramiding. Evaluation of biotic resistance/tolerance after artificial infection.
12. Principles of plot experimentation: soil variability, competition and border effect, replication, location and seasonal variation.
13. Field plot design and techniques.
14. Fenotyping systems; conventional and High-throughput plant phenotyping (HTP). Types of imaging platforms developed for field or indoor.
15. Speed breeding.
16. Methods of genetic purity assessment.

Topics of the practical works:

1. Crossing wheat or barley plants
2. Determination of putative haploid plants by flow cytometry and/or chromosoma counting.

List of the 2–5 Most Important Required Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Required literature: David A. Sleper and John M. Poehlman (2006): Breeding Field Crops, 5th Edition. ISBN 978-0-8138-2428-4/2006 pages: 19-34, 35-38, 101-112, **Pdf version of the lectures.**
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Recommended literature:
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility
Student will understand the principles of cultivar development. He/she will have skills in practical breeding like managing germplasm, executing self- and cross-pollination, using modern lab techniques, combining classical breeding selection with modern tools like high-throughput phenotyping, furthermore in experimental design and field work. He/she will know which traditional and biotechnological method can be applied at different phases of cultivar development. Student can carry out interdisciplinary communication even with the farmer community.

Course Description

Course title / Neptun code: Genome editing and transgenic technologies in plant breeding	Number of credits: 6
Course coordinator (name, position, academic degree): Antal Szőke, associate professor, PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree):	
Course type: elective	
Type of class: lecture and total number of contact hours in the semester: 16 contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): Lecture by instructor, interactive discussion and debate	
Requirements for successful completion: Colloquium	
Assessment methods applied for evaluating learning outcomes: oral exam, teacher and peer assessment	
Recommended semester 3.	
Prerequisites (if any):	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired. To introduce students to the limitations of classical plant breeding and the novelties of genetic engineering and modern genomic techniques. To provide insight into how biotechnology contributes to solving global challenges (e.g. food security, climate change). To explain the theoretical and practical application of transgenic (GMO) and new genomic techniques (NGT). To present the domestic and EU legal frameworks for genetically modified and genome-edited plants.	
Course Topics / Semester Schedule: The process of producing transgenic plants and transgenic plant breeding. Gene transformation methods. Chloroplast transformation. Global situation of genetically modified plant cultivation. Possibilities and results of transgenic plant protection: production and cultivation of herbicide, virus, bacteria, fungus, insect resistant transgenic plants. Improving the abiotic stress tolerance of plants using genetic engineering methods. Possibilities and results of genetic engineering modification of metabolic processes: carbohydrate, fatty acid, protein, flower color, ripening Possibilities and application of transgenic male sterility in hybrid breeding. Technologies that genetically limit the cultivation of GM varieties.	

Genome editing as a new opportunity in changing the hereditary properties of plants: theory and practice. Risk factors and regulation of the cultivation and consumption of genetically modified and gene-edited plant varieties.
List of the 2–5 Most Important Required Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN. Plain facts about GMOs. Hungarian White Paper. Editors: E. Balázs, D. Dudits, L. Sági (2011). Barabás Zoltán Federation of Biotechnology. ISBN 978-963-08-1066-1. Heszky L. Transzgénikus (GMO) növények: elmélet és gyakorlat. Budapest, Agrofórum (2017) , 352 p. ISBN: 978-963-12-9484-2.
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN. Alvina Gul et al (2024): Targeted Genome Engineering via CRISPR/Cas9 in Plants. Elsevier. ISBN: 978-0-443-26614-0 A. Slater, N. W. Scott, M. R. Fowler (2008): Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press. ISBN: 978-0-19-928261-6
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility Knowledge: Understanding the connections between classical and modern plant breeding methods and plant molecular genetics. Knowledge of the biochemical, molecular background and operating mechanism of transgenic (GMO), cisgenic and new genomic techniques (NGT – e.g. CRISPR/Cas systems). Knowledge of the domestic and international legal frameworks, licensing procedures and risk analysis (bioethics, coexistence) of biotechnological research and products. Ability: Understanding the principles of molecular plant breeding methods, logical structure and design of technological processes. Recognition of agricultural and environmental biotechnology problems arising in plant breeding and their scientific-based approach. Attitude: Sensitivity to the technological renewal of agriculture, modern scientific and technological breakthroughs (e.g. precision breeding). Ability to consider the benefits and socio-economic challenges of genetic engineering methods in an unbiased and fact-based manner. Autonomy: Ability to approach and implement biotechnology and breeding tasks independently with a systems approach. Awareness of the ecological, food safety and ethical responsibilities of genetic engineering and genome editing interventions. Unconditional respect for strict legal regulations, biotoxicological and ecological requirements in research and practical application.

Course Description

Course title / Neptun code: Methodology of Data Collection and Analysis / MATER079N	Number of credits: 10
Course coordinator (name, position, academic degree): László Menyhárt, Associate Professor, PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): -	
Course type: compulsory/elective	
Type of class: lecture and practical total number of contact hours in the semester: 20 contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): Real research examples and case studies are used to introduce statistical models and the principles of design of experiment and data collection. Statistical analyses are carried out during computer-based practical sessions. At the end of the course, students complete project-based data analysis assignments.	
Requirements for successful completion: exam	
Assessment methods applied for evaluating learning outcomes: Students independently conduct a statistical analysis by selecting and applying an appropriate statistical model, interpreting the results, and presenting them in a publication-ready format.	
Recommended semester: First or second	
Prerequisites (if any): -	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
The aim of the course is to provide doctoral students with a thorough understanding of modern statistical modeling and the associated methods of research design, data collection, and data analysis. The course covers the theoretical foundations of linear models, together with their most important extensions: generalized linear models (GLMs) and linear mixed models (LMMs).	
Course Topics / Semester Schedule: 1. The role of statistical modeling in scientific research. Research questions, hypotheses, variable types, data collection strategies, and experimental design. 2. Mathematical foundations of linear models, the method of least squares, model assumptions, and diagnostic methods.	

3. Analysis of variance (ANOVA) and analysis of covariance (ANCOVA) as special cases of linear models.
4. Multiple linear regression, model building, variable selection, and the treatment of interaction effects.
5. Generalized linear models (GLMs): the exponential family, link functions, and the analysis of binary, proportion, and count data.
6. Hierarchical and repeated-measures data structures and the motivation for using mixed-effects models.
7. Linear mixed models (LMMs): fixed and random effects, estimation of variance components, and maximum likelihood (ML) and restricted maximum likelihood (REML) methods.
8. Diagnostics and comparison of mixed models, prediction, and interpretation of model results.
9. Reporting statistical modeling results in scientific publications, graphical presentation of findings, and reproducible statistical analyses using R

List of the 2–5 Most Important Required Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Faraway, J. J. (2016): Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models. 2nd ed., CRC Press, ISBN: 978-1498720960

Gelman, A. & Hill, J. (2007): Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge University Press, Cambridge. ISBN: 978-0521686891

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Zuur, A. F., Ieno, E. N., Walker, N., Saveliev, A. A. & Smith, G. M. (2009): Mixed Effects Models and Extensions in Ecology with R. Springer, New York. ISBN: 978-0387874579

Pinheiro, J. C. & Bates, D. M. (2000): Mixed-Effects Models in S and S-PLUS. Springer, New York. ISBN: 978-0387989570

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

Knowledge

Understands the assumptions underlying statistical models, the principles of model selection, and the statistical aspects of experimental design and data collection. Possesses a thorough knowledge of the theoretical foundations and applications of linear models, generalized linear models (GLMs), and linear mixed models (LMMs).

Skills

Is able to select appropriate data collection and experimental design methods for a given research question. Is capable of independently fitting, evaluating, and comparing linear, generalized linear, and mixed-effects models. Is able to perform reproducible statistical analyses using the R statistical environment and to interpret and present the results to the standards of scientific research. Is capable of drawing scientifically sound conclusions from statistical analyses.

Attitude

Strives to apply the statistical methods that are most appropriate for the research question. Is open to learning and applying modern statistical modeling approaches and software tools. Is committed to scientific rigor, reproducibility, and adherence to the principles of research ethics.

Autonomy and Responsibility

Independently designs data collection and statistical analysis for research projects. Takes responsibility for the appropriate selection, documentation, and correct interpretation of statistical methods and results. Is able to justify methodological decisions in a professional setting and to critically evaluate the statistical methodology used in scientific studies.

Course Description

Course title / Neptun code: Introduction to the R programming language / MATER080N	Number of credits: 4
Course coordinator (name, position, academic degree):	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): László Menyhárt, Associate Professor, PhD	
Course type: compulsory/elective	
Type of class: practical; total number of contact hours in the semester: 20 contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): The course is based on computer-based practical sessions. Students learn to use the R programming environment through hands-on exercises with real datasets. Throughout the course, they complete independent programming and data analysis tasks that develop their skills in data management, statistical analysis, and data visualization.	
Requirements for successful completion: Project work	
Assessment methods applied for evaluating learning outcomes: The final assessment is based on a project in which students import, prepare, analyze, and visualize a dataset using reproducible R code. The evaluation criteria include the appropriate use of the R programming language, the correctness and readability of the code, the suitability of the data analysis methods applied, and the accurate interpretation and presentation of the results.	
Recommended semester: In any semester	
Prerequisites (if any): -	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
The aim of the course is to provide doctoral students with a solid foundation in the use of the R statistical programming environment, which is an essential tool for modern data analysis and statistical modeling. The course covers the fundamental programming concepts of R, its data types and data structures, methods for importing, cleaning, transforming, and managing data, as well as the basics of descriptive statistics and data visualization. Students become familiar with the principles of reproducible data analysis and develop the ability to write independent R scripts.	
Course Topics / Semester Schedule: 1. Installation of the R statistical programming environment, use of the RStudio IDE, and installation and management of R packages.	

2. Fundamentals of the R language: objects, variables, operators, functions, and the help system.
3. Data types and data structures: numeric, logical, character, and factor variables; vectors, matrices, lists and dataframes.
4. Importing and exporting data in various fileformats.
5. Data cleaning, transformation, filtering, sorting, grouping, and summarization.
6. Basic programming constructs: conditional statements, loops, and user-defined functions.
7. Calculation of descriptive statistics and generation of summary statistics.
8. Data visualization in R: creating and customizing graphical displays.
9. Reproducible data analysis: writing, documenting, and applying R scripts to real datasets.
10. Fitting linear models in R: simple and multiple linear regression, analysis of variance (ANOVA), model evaluation, and graphical diagnostics.
11. Introduction to generalized linear models and linear mixed models: principles of selecting an appropriate statistical model and an overview of the main R packages (e.g., lme4).

List of the 2–5 Most Important Required Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Wickham, H., Çetinkaya-Rundel, M. & Grolemund, G. (2023): R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. 2nd ed. O'Reilly Media, Sebastopol, CA, 576 oldal. ISBN: 978-1492097402 (Online is elérhető: https://r4ds.hadley.nz/)

Faraway, J. J. (2016): Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models. 2nd ed., CRC Press, ISBN: 978-1498720960

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Reiczigel, J., A. Harnos, and N. Solymosi (2021). Biostatisztika nem statisztikusoknak, Pars Kiadó, Nagykovácsi, Hungary, ISBN: 978-963-06-3736-7.

Kabacoff, R. I. (2022): R in Action: Data Analysis and Graphics with R and Tidyverse. 3rd ed. Manning Publications, Shelter Island, NY, 824 oldal. ISBN: 978-1617298141

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

Knowledge

Understands the structure and operation of the R statistical programming environment. Possesses knowledge of R data types and data structures, as well as methods for importing, managing, transforming, and visualizing data. Is familiar with the principles of reproducible data analysis and the implementation of basic statistical analyses in R.

Skills

Is able to use R independently for importing, cleaning, transforming, and analyzing data. Is capable of performing descriptive statistical analyses, creating data visualizations, and fitting and interpreting linear models. Is able to write well-documented, reproducible R scripts.

Attitude

Is open to applying modern statistical programming tools and workflows. Strives to produce transparent, reproducible, and well-documented data analyses. Is committed to scientific rigor, proper data management practices, and adherence to the principles of research ethics.

Autonomy and Responsibility

Independently develops reproducible data analysis workflows using R. Takes responsibility for the proper handling of data, the documentation of analyses, and the correct interpretation of results. Is able to apply the R programming environment independently to analyze and evaluate data from their own research.

Course Description

Course title / Neptun code: In vitro Plant Breeding/ GENBT136N	Number of credits: 6
Course coordinator (name, position, academic degree): Anikó Veres associate professor PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree):no	
Course type: compulsory/elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: 15 contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): The knowledge is delivered through lectures, illustrative figures, presentations, and examples from the relevant scientific literature, supplemented by practical demonstrations of *in vitro* plant culture and plant breeding methods. The consolidation of theoretical knowledge is supported by case studies, the analysis of specific examples from plant biotechnology, and individual and group-based problem-solving activities, with particular emphasis on selecting appropriate *in vitro* technologies and evaluating their potential applications.	
Requirements for successful completion: Oral examination and completion of a project assignment.	
Assessment methods applied for evaluating learning outcomes: Assessment is carried out on a scale of 1 to 5.	
Recommended semester: Not specified.	
Prerequisites (if any): *no*	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
The aim of the course is to provide students with comprehensive knowledge of the theoretical foundations and practical applications of laboratory-based (*in vitro*) culture of plant cells and tissues in modern plant breeding. The course introduces the role of biotechnological methods in increasing genetic variability, accelerating the breeding process, and developing new genotypes.	
Course Topics / Semester Schedule:	

Course topics / Semester syllabus

1. **Fundamentals of in vitro plant culture:** the principle of totipotency, pathways of organogenesis and embryogenesis, and the role of culture media and plant hormones.
2. **Techniques supporting sexual reproduction:** embryo culture, *in vitro* pollination and *in vitro* fertilization.
3. **Rapid production of homozygous lines:** haploid technologies, including androgenesis- and gynogenesis-based techniques, wide hybridization and chromosome elimination, and the Phureja technique.
4. **Mutation breeding, somaclonal variation, and in vitro selection.**
5. **Somatic hybridization:** protoplast culture and fusion.
6. **In vitro micropropagation and in vitro gene bank storage.**
7. **Production and application of artificial seeds.**

List of the 2–5 Most Important Required Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

George, E. F., Hall, M. A., & De Klerk, G.-J. (2008). *Plant Propagation by Tissue Culture. Volume 2: In Practice.* 3rd ed. Dordrecht: Springer. 501 pp. ISBN: 978-1-4020-5005-3.
Kumar, M., Muthusamy, A., Kumar, V., & Bhalla-Sarin, N. (2019). *In Vitro Plant Breeding towards Novel Agronomic Traits.* Cham: Springer.
ISBN: 978-3-030-05847-9
Taji, A., Kumar, P., & Lakshmanan, P. (2019). *In Vitro Plant Breeding.* Boca Raton, FL: CRC Press/Routledge.
ISBN: 978-0-367-13491-2

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Bhojwani, S. S., & Razdan, M. K. (1996). *Plant Tissue Culture: Theory and Practice: A Revised Edition.* Amsterdam: Elsevier. 766 pp. ISBN: 978-0-444-81623-5

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

Knowledge:
The student is familiar with the fundamental theoretical and practical methods of *in vitro* plant culture and plant reproductive biotechnology, including haploid techniques, somatic hybridization, micropropagation, and mutation breeding. The student

understands the role of culture media, plant hormones, and other culture conditions used in plant tissue culture, as well as their effects on plant regeneration and propagation.

Skills:
The student is able to identify the potential applications of *in vitro* plant culture and plant breeding methods and to select the appropriate technique for a given breeding objective. The student is able to evaluate the results of *in vitro* culture and regeneration processes and to apply the basic methods of micropropagation, haploid production, somatic hybridization, and *in vitro* selection.

Attitude:
The student is open to learning about new plant biotechnology and *in vitro* plant culture methods and strives to apply them in a modern and objective-oriented manner. In their work, the student strives for precision, compliance with experimental procedures, and objective evaluation of the results obtained.

Autonomy and Responsibility:
The student is able to independently plan *in vitro* plant culture tasks and select appropriate methods, using relevant scientific literature when necessary. The student takes responsibility for carrying out experimental work professionally and in a properly documented manner, for the reliable evaluation of results, and for complying with laboratory safety and working procedures.

Course Description

Course title / Neptun code: **Innovations in Crop Production**	Number of credits: 6
Course coordinator (name, position, academic degree): **Dr. Kovács Gergő Péter, associate professor, Phd**	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): **none**	
Course type: compulsory/**elective**	
Type of class: lecture/**seminar** / practical / consultation, and total number of contact hours in the semester: .7 contact hours (7 x 90 minutes)	
Given the small group size, classes are held in an interactive, seminar-like format: students prepare a literature review linked to their own research topic.	
Requirements for successful completion: **term mark**	
Assessment methods applied for evaluating learning outcomes: **Assessment of a written assignment, graded on a five-grade scale.**	
Recommended semester **4**	
Prerequisites (if any): ***none***	
Course Description The aim of the course is to provide doctoral students with an overview of the scientific and technological developments of the past decade in crop production, together with the framework conditions driving them: climate change, the changing regulatory environment and sustainability requirements. The course covers the renewal of tillage systems, the diversification of cropping structure, precision and digital technologies, remote sensing, new directions in plant protection, and crops for alternative uses. The emphasis is not on a detailed description of individual technologies, but on enabling students to evaluate new solutions simultaneously from agronomic, environmental and economic perspectives. Each topic is discussed through current international literature,	

addressing the limits of the generalisability of published results and their adaptability to Hungarian growing conditions.

Course Topics / Semester Schedule:

 The changing framework conditions of crop production: climate change and weather extremes, the EU and Hungarian regulatory environment, sustainability and market expectations. Current main directions of crop production research.

 The renewal of tillage systems: conservation and no-till technologies, the concept and measurability of soil health, soil organic carbon dynamics, the agronomic realities of carbon farming.

 Crop rotation and diversification: cover crops, intercropping, extended crop rotation. Agronomic and economic evaluation of regenerative practices, documented yield effects and their limitations.

 Precision crop production: site-specific nutrient management and plant protection, variable rate application, sensor technology, autonomous and semi-automated machinery, and questions of return on investment.

 Remote sensing and digital decision support: drone- and satellite-based data sources, vegetation indices, crop growth models, agrometeorological forecasting, applications of machine learning and their data quality pitfalls.

 New directions in plant protection: integrated pest management in the wake of active substance withdrawals, forecasting models, biological plant protection products and microbial preparations, and questions of resistance management.

 Alternative and energy crops, the utilisation of marginal lands, biomass-based value chains and the crop production aspects of the bioeconomy.

List of the 2–5 Most Important Required Literature

(textbooks, lecture notes, or other study materials)

Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Lecture material

List of the 2–5 Most Important Recommended Literature

(textbooks, lecture notes, or other study materials)

Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Lecture material
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility
Knowledge: The student is familiar with the most recent scientific results and technological development directions in crop production, and with the level of scientific evidence supporting them. They understand the site-specific, agronomic and economic preconditions of each innovation, as well as the underlying regulatory framework. *Skills:* The student is able to critically process international literature and to judge the validity limits of experimental results. They are able to evaluate a new technology simultaneously from agronomic, environmental and economic perspectives, to position their own research topic within international research directions, and to defend their position in professional debate. *Attitudes:* The student is open to new technological and methodological solutions, while remaining consistently critical of claims that lack supporting evidence. They are committed to sustainable farming practice and to the norms of scientific ethics. *Autonomy and responsibility:* The student independently forms and represents a professional position on contested questions. They take responsibility for their conclusions and advisory recommendations, weighing their environmental, economic and social consequences.

Course Description

Course title / Neptun code: **Scientific Research Workshop, NOVTR250N**	Number of credits: **6**
Course coordinator (name, position, academic degree): Zoltán Kende, Associate Professor, PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): Ákos Tarnawa, Associate Professor, PhD	
Course type: compulsory/**elective**	
Type of class: lecture/seminar / **practical** / consultation, and total number of contact hours in the semester: **26 contact hours**	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods):**Journal club discussions, project-based learning, critical literature analysis, case studies, reproducible data analysis, R/Python exercises, oral presentations, supervised independent research, peer discussion.**	
Requirements for successful completion: **Successful completion of the project work (portfolio assessment).**	
Assessment methods applied for evaluating learning outcomes: **Portfolio assessment, evaluation of the manuscript draft, oral presentation and defence, assessment of individual assignments, and active participation in discussions.**	
Recommended semester **3rd semester**	
Prerequisites (if any): **none.**	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
This course builds on the theoretical courses previously completed during the doctoral programme that focus on scientific publishing and dissertation writing. It complements the acquired knowledge through practical, small-group workshop activities. The course is organised as a **journal club**, in which students regularly conduct critical analyses of high-quality international scientific publications, with particular emphasis on research methodology, data analysis approaches, scientific reasoning, and the logical structure of scientific manuscripts. A key component of the course is collaborative, reproducible data analysis. Participants work with their own datasets (or jointly developed example datasets), covering the entire analytical workflow from planning the analysis and correctly interpreting statistical results to producing publication-quality figures and tables. The course also integrates modern research practices, including efficient reference management, the responsible use of artificial intelligence, R- and Python-based data analysis and visualisation, and effective scientific presentation techniques.	

Course Topics / Semester Schedule: • Scientific publishing process • Critical analysis of scientific papers • Research planning • Statistical analysis and reproducible research • Data visualization in R/Python • Responsible use of AI in research • Scientific writing • Preparing publication-quality figures and tables • Scientific presentations • 10. Portfolio presentation and discussion
List of the 2–5 Most Important Required Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Gastel, B., & Day, R. A. (2024). How to Write and Publish a Scientific Paper (9th ed.). Cambridge University Press. 376 p. ISBN: 978-1-009-47753-6. Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, J., & FitzGerald, W. T. (2024). The Craft of Research (5th ed.). University of Chicago Press. 368 p. ISBN: 978-0-226-82667-7
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
Alley, M. (2013). The Craft of Scientific Presentations: Critical Steps to Succeed and Critical Errors to Avoid (2nd ed.). Springer. xix + 286 p. ISBN: 978-1-4419-8278-0 Silvia, P. J. (2019). How to Write a Lot: A Practical Guide to Productive Academic Writing (2nd ed.). American Psychological Association. 149 p. ISBN: 978-1-4338-2973-4
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility
Knowledge: scientific publishing, research methodology, statistics. **Skills:** scientific writing, critical evaluation, data analysis, presentation skills. **Attitude:** scientific integrity, critical thinking, openness to peer review, openness for new technologies.

Autonomy and responsibility: independent research planning, responsible data management, ethical publication practices.

Course Description

Course title / Neptun code: Applied soil microbiology	Number of credits: 6
Course coordinator (name, position, academic degree): Dr. Gábor Csitári, Associate Professor, PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): ---	
Course type: elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: 60 contact hours	
Teaching methods: Knowledge is transferred through the application of seminars, laboratory practicals, case studies, and the processing of scientific literature.	
Requirements for successful completion: Examination (colloquium)	
Assessment methods applied for evaluating learning outcomes: report / oral assessment, term paper / assignment, exam	
Recommended semester: elective	
Prerequisites (if any): ---	
Course Description The objective of the course is to provide knowledge on soil microbial communities, their role in the development of soil fertility, and the impacts of natural and anthropogenic factors on soils. Special emphasis is placed on the applicable analytical methods and their evaluation.	
Course Topics / Semester Schedule: - Main groups and characteristics of organisms found in the soil. - Methods for measuring the characteristics (quantity, activity, diversity) of soil microbial communities, and the interpretation of measurement data. - Biological activity of soils. Bound and free enzymes in the soil. - Soil processes of the biogeochemical carbon cycle. - Soil processes of the biogeochemical nitrogen cycle. - Interactions between plants and microorganisms. - Soil biological effects of agrochemical use in agriculture. - Soil biological effects of fertilizers. - Degradation and detoxification of xenobiotics. - Effects of soil tillage and management practices on soil microorganisms.	
List of the 2–5 Most Important Required Literature - Eldor, A.P.: *Soil microbiology, ecology and biochemistry*. Elsevier Science & Technology Books, 2017.	

- Buscot, F. and Warma, A.: *Microorganisms in soils: roles in genesis and functions*. Springer-Verlag Berlin Heidelberg, 2005.
List of the 2–5 Most Important Recommended Literature - Szabó I. M.: *Az általános talajtan biológiai alapjai.* Mundus Magyar Egyetemi Kiadó, Budapest, 2008. - Horváth E. (ed.): *Talajtan és talajökológia.* Pannon Egyetem, Veszprém, 2012. (uni-pannon.hu)
Professional Competences Developed by the Course The Applied soil biology course significantly contributes to the development of professional competences required in the fields of modern agriculture and environmental protection. It enhances diagnostic, analytical, and problem-solving skills. It provides an ecological and systemic perspective, with openness to the practical application of the latest scientific results. It supports ethical operation related to professional responsibility.

Course Description

Course title / Neptun code: Insect pheromones – chemical ecology / SDINTD8_006EN	Number of credits: 8
Course coordinator (name, position, academic degree): Szőcs Gábor, professor emeritus, DSc	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): -	
Course type: compulsory/elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: 16 contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): case presentations, interactive lectures, introducing special sophisticated instruments	
Requirements for successful completion: oral exam	
Assessment methods applied for evaluating learning outcomes: The students should be able to analyse situations and develop tentative solutions	
Recommended semester: 1	
Prerequisites (if any): -	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
Innovative responses to challenges posed by newly arriving invasive agricultural pests in the view of chemical ecology. The course covers key features of semiochemical communication by plant volatiles and insect pheromones, including their environmental and physiologial control, biosynthesis, release, perception and behavior. The focus is on effective practical application of semiochemicals for pest monitoring and control, in the frame of sustainable concepts and strategies.	
Course Topics / Semester Schedule: Establish basic knowledge, which enables orientation in the field of chemical ecology and helps in selecting proper plant protection methods against newly arrived, invasive pests.	
List of the 2–5 Most Important Required Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.	

Bozsik, G., Molnár, B.P., Domingue, M.J., Szőcs, G. (2023): Changes to volatile profiles of arborvitae, *Thuja occidentalis*, from drought and insect infestation: olfactory cues for the cypress bark beetle, *Phloeosinus aubei.* Chemoecology https://doi.org/10.1007/s00049-023-00389-9

Dömötör, I., Kiss, J., **Szőcs**, G. 2007: First results on synchrony between seasonal pattern of pheromone trap captures of cotton bollworm, *Helicoverpa armigera* and appearance of freshly emerged larvae on developing cobs of corn hybrids. J. Pest Sci. 80: 183-189. DOI: 10.1007/s10340-007-0164-y

Jermy, T., Szentesi, Á., Tóth, M., **Szőcs**, G. 2006. Pest control: from chemical ecology to evolution. A Hungarian perspective. Acta Phytopathol et Entomol. Acad. Sci. Hung. 41: 121-135. https://akjournals.com/view/journals/038/41/1-2/article-p121.xml

Szőcs, G. 2014. When to spry? Examples on incorporation of time-series of pheromone trap captures into plant protection technology. IOBC-WPRS Bull. 99: 123-128. https://iobc-wprs.org/product/when-to-spray-examples-on-incorporation-of-time-series-of-pheromone-trap-captures-into-plant-protection-technology/

Witzgall P., Kirsch P., Cork A. (2010): Sex Pheromones and Their Impact on Pest Management. J. Chem. Ecol. 36(1): 80-100. DOI: 10.1007/s10886-009-9737-y

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Mucignat-Caretta, Carla (ed.) (2014): Neurobiology of Chemical Communication. CRC Press, Taylor & Francis Group, Boca Raton London, New York. pp. 580.

For Hungarian speakers, see also:

Molnár B.P., Szőcs G. (2023): A csábítás illatai – A feromonok és a kairomonok szerepe a lepkék életében. (The scents of allures – the role of pheromones and kairomones in the life of Lepidoptera.) Kaleidoszkóp Könyvek. HUN-REN Magyar Kutatási Hálózat – Libri ISBN 978-963-604-135-9. ISSN 2939-8185. Budapest, pp. 153. (In Hungarian. Popular Science - ismeretterjesztő)

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

In case of emerging threats posed by new, invasive insect pests, special skills to contribute to developments of special monitoring and control methods in the frame of chemical ecology, within the concept of sustainable agriculture.

Course Description

Course title / Neptun code: **Cereal biotechnology**	Number of credits: 6
Course coordinator (name, position, academic degree): János Pauk, professor, DSc	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): Csaba Lantos, head of laboratory, DSc.	
Course type: elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: 16-hour lectures + 10 hours practices = 26 contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): - lectures illustrated with PPT - laboratory practice, methodological elements performed by students - consultation related to the student's PhD topic (if necessary)	
Requirements for successful completion: oral exam	
Assessment methods applied for evaluating learning outcomes: mark	
Recommended semester spiring semester (2^{nd} or 4^{th})	
Prerequisites (if any): *MSc genetics-, plant biotechnology-, plant breeding studies*	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
Cereal crops (wheat, barley, rice, triticale, rye, maize, sorghum) are essential species for world agriculture. The haplod- and diploid plant biotechnologies of the different species are well developed after research of the past decades. The aim of the course is to introduce haploid (androgenesis induction, breeding application) and diploid biotechnology methods (callus induction, cell-plant system, cell-level selection, genetic transformation, gene editing, plant regeneration) to the participants of the training in the lectures (16 hours). The aim of the exercises (10 hours) is to review the methodological elements and to learn them manually. At the lectures, we will introduce the application of biotechnological methods and deepen them in laboratory exercises. At the end of the course in the spring semester, we visit the cereal nursery of the Cereal Research Ltd. in Szeged, with special regard to the strains and varieties made in the Biotechnology Laboratory of CR Ltd..	

Course Topics / Semester Schedule: Topics of the course/semester themes: 1. Introduction to the topic of cereal biotechnology. Tasks to be solved. 2. *In vitro* androgenezis 2.1. Anther culture 2.2 Microspore culture 2.3. Breeding use of DH plants 3. Somatic cultures of cereals 3.1. Induction of somatic cultures 3.2. Cell-plant system 3.3. Cellular-level selection 3.4. Transgenic techniques in cereals 3.5. Gene editing and its application in cereals 4. Results of maize biotechnology 5. Rice biotechnology achievements 6. The biological risk of biotechnological methods 7. Laboratory practice. methodological implementation of the material of the theoretical lessons 8. Consultation on topics covered in theoretical and practical lessons
List of the 2–5 Most Important Required Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
- PDF copies of the lectures - J.M.Sequi-Simaro (2021): Method in Molecular Biology. Volume General topics, Cereals, Springer protocols, Humana Press, 187-360 pp. - Some relevant copies of the most important publications
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.
H.D.,Jones, P.R. Shewry (2009): Transgenic wheat, barley and oats, Springer protocols, Humana Press, 1-345.
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge, Skills, Attitudes, Autonomy and Responsibility
Students will learn about the most important achievements in the biotechnology of cereals. During the exercises, most of the basic methods are performed manually. They will be able to carry out independent research, or perhaps to start research on an own

research topic. Later, as researchers, they can work with the known plant biotechnological methods.

Course Description

Course title / **Advanced IPM**	Number of credits: **8**
Course coordinator (name, position, academic degree): **Jozsef Kiss, Professor, Head of Dept. PhD, AM AAF (Associate Member of the French Academy of Agriculture)**	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): **NO**	
Course type: compulsory/**elective**	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: ....**28 hrs**..... contact hours	
Teaching methods and specific educational tools used for knowledge transfer: **case presentations, case-study analyses, literature &international websites, Team work**	
Requirements for successful completion: **in person oral Team exam**	
Assessment methods applied for evaluating learning outcomes: level of their performance along the course and in their final exam. **Oral exam, pptx presentation in 2 members' Team, Group discussion**	
Recommended semester **NO**	
Prerequisites (if any): **NO**	
Course Description	
Understanding IPM according to UN Sustainable Developmental Goals, UN FAO materials, EU Greening and Farm2Fork, EU SUD and SUR, new innovative IPM solutions (NGT, RNAi), placing IPM in to policy and broad spatial, temporal scale	
Course Topics / Semester Schedule: **N/A**	
List of the 2–5 Most Important Required Literature.	
M. Barzman*, P. Bàrberi, A.N.E. Birch, P.M. Boonekamp, S. Dachbrodt-Saaydeh, B. Graf, B. Hommel, J.E. Jensen, **J. Kiss,** P. Kudsk, J.R. Lamichhane, A. Messéan, A.C. Moonen, A. Ratnadass, P. Ricci, J.L. Sarah, M. Sattin (2015): Eight principles of integrated pest management. *Agron. Sustain. Dev*. 35:1199–1215. DOI 10.1007/s13593-015-0327-9 Lamichane, J.M; Messean, A; Akbas, C; Andreasen, CB; Arendse, W; Bluemel, S; Dachbrodt-Saaydeh, S; Fuchs, A; Jansen, J.P; **Kiss, J**; Kudsk, P; Larena, I; Malet, JC; Marzetti, A; and Zweifel, J. (2016): Strategic Res. Agenda for IPM in Europe. INRA France, 36p. **Kiss J**., Delos, M. (2020): Implementing biopesticides as part of an integrated pest management (IPM) programme. http://dx.doi.org/10.19103/AS.2020.0073.03 Chapter taken from: Birch, N. and Glare, T. (ed.), *Biopesticides for sustainable agriculture*, Burleigh Dodds Science Publishing, Cambridge, UK, 2019, (ISBN: 978 1 78676 356 3; www.bdspublishing.com.	

List of the 2–5 Most Important Recommended Literature
S.I. Tarigan, Sz. Toth, M. Szalai, **J. Kiss**, Gy. Turoczi & S. Toepfer (2022): Biological control properties of microbial plant biostimulants. A review. Biocontrol Science and Technology, DOI: 10.1080/09583157.2022.2129589 Farm to Fork Strategy (European Commission): https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf Lamichhane, JM., B. Akbas, C.B. Andreasen, W. Arendse, S. Bluemel, S. Dachbrodt-Saaydeh, A. Fuchs, J.P. Jansen, **J. Kiss**, P. Kudsk, J.C. Malet, A. Masci, A. de la Peña, A. Willener and A. Messéan (2018): A call for stakeholders to boost Integrated Pest Management in Europe: A vision based on the three-year European research area network project. *International Journal of Pest Management,* https://doi.org/10.1080/09670874.2018.1435924 Antier C. Andersson R. Auskalnienė O. Barić K. Baret P. Besenhofer G. Calha I., Carrola Dos Santos S., De Cauwer B., Chachalis D., Dorner Z., Follak S., Forristal D., Gaskov S., Gonzalez, Andujar J. L. Hull R., Jalli H., Kierzek R., **Kiss J**., Kudsk P., Leonhardt C., Leskovšek R., Mennan, H., Messean A., Ņečajeva J , Mullins E., Neve P., Pedraza V., Pintar A., Reboud X., Redl M., Riemens M., Ringselle B., Ruuttunen P., Sattin M. Simić M. Soukup J. Stefanic E., Steinkellner, S. Storkey J. Ulber L., Weickmans B., Wirth J. (2020). A survey on the uses of glyphosate in European countries. INRAE. https://doi.org/10.15454/A30K-D531 Nduwayo, P.; Schaffner, U.; Tarigan, S.I.; Dorner, Z.; **Kiss, J**.; Desneux, N.; Lesieur, V.; Rousset, Z.; Müller-Schärer, H.; Toepfer, S. (2025) Risk Assessment Approaches for *Ophraella communa* as a Biological Control Agent for *Ambrosia artemisiifolia* in Agricultural Landscapes of Southeastern Central Europe: A Review. Agronomy **2025**, 15, 1771. https://doi.org/10.3390/agronomy15081771 Ounis, S.; Turóczi, G.; **Kiss, J**. Arthropod Pests, Nematodes, and Microbial Pathogens of Okra (Abelmoschus esculentus) and Their Management—A Review. Agronomy **2024**, 14, 2841. https://doi.org/10.3390/agronomy14122841 Regulation (EU) 2026/1388 of the European Parliament and of the Council of 17 June 2026 on plants obtained by certain new genomic techniques and their products, and amending Regulation (EU) 2017/625.
Professional Competences Developed by the Course
Overall personal capacity development, critical analist capacity and external communication improvement, understanding and responding to global/regional /national challenges, collaborative (Team) working development

Course Description

Course title / Neptun code: AI in animal breeding	Number of credits: 6
Course coordinator (name, position, academic degree): György Kövér, associate professor, PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree):	
Course type: compulsory/elective elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: .18/18/36..... contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): presentations, case-study analyses and project based homework	
Requirements for successful completion: Students choose an AI method covered and apply it to a question connected to their own research area. The result must be presented.	
Assessment methods applied for evaluating learning outcomes: exam	
Recommended semester	
Prerequisites (if any):	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
The use of artificial intelligence tools appears in nearly every area of animal husbandry research. Building on machine learning methods, we can analyse data measured during precision livestock farming and images generated through computer vision. The course is introductory in nature. We present individual application possibilities topic by topic. Students will be able to determine, for any given AI method, whether it is applicable to their own research. During computer lab exercises, we demonstrate the methods by analysing databases using freely available applications. AI tools form an essential part of the course material. Their use must comply with MATE's relevant guidelines.	
Course Topics / Semester Schedule: • Introduction. A survey map of where AI already touches the animal Research. • Supervised vs. unsupervised learning, neural networks, validation, overfitting, the 'trained model'.	

- Computer Vision — Detecting and Tracking Animals, pose estimation, behavior classification.
- AI for Wildlife Monitoring and Conservation. Camera-trap image classification.
- Precision Livestock Farming. Sensor and computer-vision systems. Welfare and health monitoring, behavior detection.
- AI in Veterinary Diagnostics.
- Genomic selection, GWAS combined with machine learning.
- AI and the 3Rs: Replacement Technologies (replacement, reduction, refinement)
- FAIR data principles, dataset bias, validation.
- Ethics, Welfare & Governance of AI in Animal Research
- LLMs in the Research Workflow. synthesis, hypothesis generation. Hallucination.

List of the 2–5 Most Important Required Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

1. Akbarein, H., Taaghi, M. H., Mohebbi, M., & Soufizadeh, P. (2025). Applications and considerations of artificial intelligence in veterinary sciences: A narrative review. *Veterinary Medicine and Science, 11*(3). https://doi.org/10.1002/vms3.70315 https://pmc.ncbi.nlm.nih.gov/articles/PMC11964155/
Publisher: Wiley · ISSN: 2053-1095 · DOI: 10.1002/vms3.70315 · Open-access copy: PMC11964155

2. Tuia, D., Kellenberger, B., Beery, S., Costelloe, B. R., Zuffi, S., Risse, B., Mathis, A., Mathis, M. W., van Langevelde, F., Burghardt, T., Kays, R., Klinck, H., Wikelski, M., Couzin, I. D., Van Horn, G., Crofoot, M. C., Stewart, C. V., & Berger-Wolf, T. (2021). Seeing biodiversity: Perspectives in machine learning for wildlife conservation *(arXiv:2110.12951)*. arXiv. https://arxiv.org/abs/2110.12951 https://arxiv.org/abs/2110.12951
Format: arXiv preprint · No formal journal, publisher, or DOI attached to the preprint itself

3. Neethirajan, S., Scott, S., Mancini, C., Boivin, X., & Strand, E. (2024). Human-computer interactions with farm animals—enhancing welfare through precision livestock farming and artificial intelligence. *Frontiers in Veterinary Science, 11*, Article 1490851. https://doi.org/10.3389/fvets.2024.1490851 https://pmc.ncbi.nlm.nih.gov/articles/PMC11604036/
Publisher: Frontiers Media SA · Published: November 14, 2024 · DOI: 10.3389/fvets.2024.1490851 · PMID: 39611113 · PMCID: PMC11604036

4. Foris, B., Sheng, K., Dürnberger, C., Oczak, M., & Rault, J.-L. (2025). AI for one welfare: The role of animal welfare scientists in developing valid and ethical AI-based welfare assessment tools. *Frontiers in Veterinary Science, 12*, Article 1645901. https://doi.org/10.3389/fvets.2025.1645901

https://www.frontiersin.org/journals/veterinary-science/articles/10.3389/fvets.2025.1645901/full
Publisher: Frontiers Media SA · DOI: 10.3389/fvets.2025.1645901

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

Knowledge
- Is familiar with the categories of AI methods usable in animal breeding research
- Knows several suitable computer tools for solving AI tasks

Skills
- Is able to select AI tools applicable to their own field
- Is able to independently evaluate computational results
- Is able to explain the results in an accessible way

Attitudes
- Is open to keeping up with developments in AI tools

Autonomy and Responsibility
- Uses AI tools responsibly, taking their drawbacks into account.
- Adheres to the principles of ethical research.

Course Description

Course title / Neptun code: **Soil Water Management and the Environment**	Number of credits: **6**
Course coordinator (name, position, academic degree): **Dr. András Makó, Research Professor, DSc**	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): -	
Course type: compulsory / elective	
Type of class: **lecture** / seminar / practical / consultation, and total number of contact hours in the semester: **30** contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): Power Point presentation	
Requirements for successful completion: colloquium	
Assessment methods applied for evaluating learning outcomes: oral examination with performance-based grading	
Recommended semester: -	
Prerequisites (if any): -	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
Within the framework of the course, participants gain an overview of soil as a three-phase polydisperse system. They examine in detail the characteristics and formation of the solid, liquid and gaseous phases of soil, and their roles in soil material-cycling processes and in the various functions of soil (biomass production, buffering medium, natural filtration system, etc.). They acquire methods for the field and laboratory determination of key properties and for the evaluation and interpretation of measurement data, as well as ways of applying these results to regulate the soil water regime and material cycling. Particular emphasis is placed on the environmental relationships of the soil solid phase and water regime, their links to soil degradation processes (water and wind erosion, salinisation, acidification and structural degradation), soil nutrient cycling, soil contamination, and surface-water and groundwater resources (quantity and quality).	
Course Topics / Semester Schedule:	

- Structure of soils. Mineral constituents of soils. Major silicate minerals in soils. Classification and properties of clay minerals.
- Primary soil particles. The concept and analysis of particle size distribution.
- Soil structure. Interpretation and description of soil structure. Biological, chemical and physical factors of soil-structure formation.
- Soil structure and porosity. Soil pores. Soil structure and hydraulic conductivity. Structural stability and structural degradation.
- Soil water content. Interactions between water and soil. Swelling and shrinkage of soils. Effects of swelling and shrinkage on soil structure. Soil cracking.
- Water retention capacity of soils. Soil water potential. Capillarity of soils. Hysteresis associated with soil moisture content.
- Field and laboratory methods for measuring soil water content and soil water potential.
- Fundamental laws of water movement in saturated soils. Darcy's law. Water flow in saturated soils. Factors affecting hydraulic conductivity. Field and laboratory measurement of soil hydraulic conductivity.
- Fundamental laws of water movement in unsaturated soils. Capillary water movement in soils and its types. Infiltration and permeability. Unsaturated hydraulic conductivity. Measurement methods.
- Pedotransfer functions.
- Groundwater. Natural and artificial drainage of soils. Methods for investigating groundwater pressure conditions and flow velocity.
- Soil water management - management of soil water content. Soil water-holding capacity. Soil water balance.
- Soil-physical foundations of irrigation and drainage.
- Soil consistency. Soil strength. Soil compaction.
- Soil degradation processes.
- Soil-physical aspects of soil erosion and erosion control. Harmful effects of soil erosion. Water erosion and its forms. Estimation of erosion losses using models. Wind erosion (deflation). Principles of erosion control.
- Movement of chemicals in soils (readily and sparingly water-soluble compounds).
- Soil and soil-physical databases and their potential applications.
- Soil-physical foundations of soil advisory services.

List of the 2–5 Most Important Required Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

- Stefanovits, P. - Filep, Gy. - Füleky, Gy.: Talajtan. Mezőgazda Kiadó, 1999.
- Búzás, I. (ed.): Talaj- és agrokémiai vizsgálati módszerkönyv 1-2. INDA 4231 Kiadó, 1993.

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

- Di Gléria, J. - Klimes-Szmik, A. - Dvoracsek, M.: Talajfizika és talajkolloidika. Akadémiai Kiadó, Budapest, 1957.
- Ballenegger, R. - Di Gléria, J.: Talaj- és trágyavizsgálati módszerek. Mezőgazdasági Kiadó, Budapest, 1962.
- Várallyay, Gy. (1985): Magyarország talajainak vízháztartási és anyagforgalmi típusai. Agrokémia és Talajtan, 34, 267-298.
- Várallyay, Gy. (2003): A mezőgazdasági vízgazdálkodás talajtani alapjai. Egyetemi jegyzet. FVM Vízgazd. Osztály, Budapest-Gödöllő.
- Várallyay, Gy. - Szücs, L. - Rajkai, K. - Zilahy, P. - Murányi, A. (1980): Magyarországi talajok vízgazdálkodási tulajdonságainak kategóriarendszere és 1:100 000 méretarányú térképe. Agrokémia és Talajtan, 29, 77-112.

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

The student acquires system-level knowledge of soil structure, soil water regime and water movement processes, including their environmental and soil conservation implications. They can measure and evaluate key soil physical properties, interpret measurement and database data, and formulate sound recommendations to improve soil water management and mitigate degradation. They work accurately, objectively and with a sustainability-oriented approach, independently identify and analyse soil physical problems, and take responsibility for the methods applied and conclusions drawn.

Course Description

Course title / Neptun code: **Applied Experimental Studies in Crop Science/ NOVTR249N**	Number of credits: **6 credits**
Course coordinator (name, position, academic degree): **Ákos Tarnawa, Associate Professor, PhD**	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): **Zoltán Kende, Associate Professor, PhD**	
Course type: compulsory/**elective**	
Type of class: **lecture**/seminar / **practical** / consultation, and total number of contact hours in the semester: **26 contact hours**	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): **case studies; thought experiments and experimental design; project-based assignments; design and implementation of students' own experiments; interpretation**	
Requirements for successful completion: **project-based assessment of practical work**	
Assessment methods applied for evaluating learning outcomes: **description and presentation of project, discussion**	
Recommended semester **2nd semester**	
Prerequisites (if any): **none**	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired. The course Applied Experimental Studies in Crop Science, offered within the framework of the PhD programme, provides an empirical foundation for research in agricultural and plant sciences. It builds upon the theoretical disciplines underlying experimental design, including biometrics, statistics, and mathematical modelling, while addressing the methodology of practical experimentation through an integrated approach. The aim of the course is to enable students to independently design, implement, and critically evaluate complex experiments, with particular emphasis on the specific characteristics and challenges of experimental research in crop science. The scope of the course is not limited to field experiments; it also encompasses the planning and implementation of studies conducted under laboratory, phytotron, pot, and other controlled conditions. Particular emphasis is placed on demonstrating the methodological differences and connections among various experimental environments, as well as on translating the theoretical principles of experimental design — including randomisation, replication, blocking, and factorial designs — into practical implementation.	

The course addresses in detail the planning and practical implementation of experiments, including the design of experimental plot layouts, the technical execution of treatments, and the specific characteristics and limitations associated with the use of plot-scale machinery and equipment. Special attention is given to the identification and minimisation of sources of experimental error during both field operations — including sowing, treatment application, and harvesting — and sampling and measurement procedures.
The course also examines methodological issues related to laboratory measurements and analytical procedures, with particular emphasis on the fact that problems arising during measurement and data processing can often be traced back to inadequate experimental design. Students will become familiar with the critical points of data collection, validation, and processing, as well as with common pitfalls that may lead to biased or misleading conclusions.
The course adopts an interdisciplinary approach, integrating the theory of experimental design with crop production technologies, technical and engineering solutions, and data analysis. By the end of the course, students will be able to conceptually develop complex experimental systems, critically evaluate their practical implementation, and interpret the resulting data and findings on a sound methodological basis.

Course Topics / Semester Schedule:

- Organisation of scientific research
- Classification of experiments and experimental work
- Fundamental concepts of experimental work
- Specific characteristics of field experiments
- Design of field experiments
- Setting up field experiments (practically)
- Planning and implementation of measurements in field experiments

List of the 2–5 Most Important Required Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Berzsenyi Zoltán: Növénytermesztési kísérletek tervezése és értékelése, AGROINFORM Kiadó, Budapest, 2016.; ISBN 978-963-502-954-9
Tomcsányi Pál: Általános kutatásmódszertan, Szent István Egyetem, Gödöllő, 2000.; ISBN: 963-86097-0-2
Salmon, S. C. – Hanson, A. A.: A mezőgazdasági kutatás elméleti és gyakorlati problémáiról, Mezőgazdasági Kiadó, Budapest, 1970.

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

I'só István – Berzsenyi-Janovits László: A szántóföldi kísérletek technikája, Mezőgazdasági Kiadó, Budapest, 1961.

Sváb János: Útmutató – szántóföldi kísérletek elrendezésére és értékelésére varianciaanalízissel, Mezőgazdasági Kiadó, Budapest, 1959.

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

Knowledge

- has a thorough knowledge of the principles and structure of rigorous scientific experiments
- understands the specific characteristics of different types of experiments
- is aware of the limitations of scientific experiments

Skills

- is able to design rigorous scientific experiments
- is able to set up and implement scientific experiments
- is able to maintain and manage scientific experiments
- is able to systematically record experimental results

Attitudes

- demonstrates an interest in new scientific findings
- applies an analytical approach to scientific problems
- demonstrates an interest in new technological solutions

Autonomy and responsibility

- independently designs experiments
- is able to identify and recognise new scientific findings
- is able to distinguish scientifically interpretable results from incidental or secondary outcomes
- is capable of contributing to methodological development and improvement

Course Description

Course title / Neptun code: **Crop Pathogens**	Number of credits: 8
Course coordinator (name, position, academic degree): **Dr. Rita Bán, professor, PhD**	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): -	
Course type: compulsory/elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: 28 contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): case presentations, project-based learning	
Requirements for successful completion: oral exam	
Assessment methods applied for evaluating learning outcomes: 5 grade (1-5)	
Recommended semester: autumn	
Prerequisites (if any): -	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired. The course aims to provide doctoral students with an advanced and interdisciplinary understanding of the major crop pathogens (related to the students' areas of interest) threatening global crop production. Emphasis is placed on the biology and epidemiology of economically important pathogens, the influence of climate change on plant disease dynamics, and the complex interactions among pathogens, host plants, and the environment. Upon successful completion of the course, doctoral students will be able to demonstrate an advanced understanding of the biology, diversity, epidemiology, and global significance of economically important plant pathogens affecting agricultural crops.	
Course Topics / Semester Schedule: Poliphag plant pathogens of worldwide occurrence; Dangerous crop pathogens; Climate change and crop diseases; Integrated pest management against crop pathogens; Biostimulants and botanical pesticides against crop diseases; Future perspectives of disease control.	
List of the 2–5 Most Important Required Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.	

Galli, M., Feldmann, F., Vogler, U.K. *et al.* Can biocontrol be the game-changer in integrated pest management? A review of definitions, methods and strategies. *J Plant Dis Prot* **131**, 265–291 (2024). https://doi.org/10.1007/s41348-024-00878-1 Richard, B., Qi, A. & Fitt, B.D.L. (2022) Control of crop diseases through Integrated Crop Management to deliver climate-smart farming systems for low- and high-input crop production. *Plant Pathology*, 71, 187–206. https://doi.org/10.1111/ppa.13493
List of the 2–5 Most Important Recommended Literature (textbooks, lecture notes, or other study materials) Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN. Chen, W.; Modi, D.; Picot, A. Soil and Phytomicrobiome for Plant Disease Suppression and Management under Climate Change: A Review. *Plants* **2023**, *12*, 2736. https://doi.org/10.3390/plants12142736 Cucu, M.A.; Choudhary, R.; Trkulja, V.; Garg, S.; Matić, S. Utilizing Environmentally Friendly Techniques for the Sustainable Control of Plant Pathogens: A Review. *Agronomy* **2025**, *15*, 1551. https://doi.org/10.3390/agronomy15071551
Professional Competences Developed by the Course Please specify the professional competences, competence elements and skills to which the course substantially contributes, including: Knowledge: Possess advanced and up-to-date knowledge of the epidemiology and economic importance of some major crop pathogens worldwide. Skills: Increased analytical skills connected to the topic. Attitudes: Value sustainable agriculture and integrated pest management. Autonomy and Responsibility: demonstrate professional responsibility in promoting sustainable crop production, plant health, and global food security.

Course Description

Course title / Neptun code: **Herbology, NVVED074N**	Number of credits: **8**
Course coordinator (name, position, academic degree): **Dr. Dorner Zita, associate professor, PhD**	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree):	
Course type: compulsory/**elective**	
Type of class: **lecture**/seminar / **practical** / consultation, and total number of contact hours in the semester: **28 contact hours**	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): **The transfer of knowledge is achieved through the integration of theoretical and practical knowledge, with active student participation.**	
Requirements for successful completion: **colloquium**	
Assessment methods applied for evaluating learning outcomes: **oral exam, presentation**	
Recommended semester: **First semester (autumn)**	
Prerequisites (if any):	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
The aim of the course is to develop student weed diagnostic competencies. Within the framework of the course, students become familiar with weed species of national and international importance and acquire the fundamentals of weed life form systems and regeneration biology. They gain detailed knowledge of the characteristic weed species occurring in arable crops, plantations, and ruderal habitats. Students become familiar with the most important invasive plant species, as well as the causes and mechanisms of their spread.	
Course Topics / Semester Schedule: • The most important weed species worldwide and in Hungary; methodology and results of the National Weed Surveys • Life-form classification and regeneration biology of weed species • Weed species of cultivated land (cereal crops, row crops, and perennial plantations) • Weed species of ruderal habitats, field margins, and roadsides • Parasitic plants (*Cuscuta, Orobanche* species) • Comparison of grass weed species based on morphological characteristics	

- Weed seedling identification
- Weed diagnostics (group work and field practice in weed identification)
- Invasion biology and invasive weed species

List of the 2–5 Most Important Required Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Botta-Dukát, Z. and Balogh, L. (ed.) (2008): The most important invasive plants in Hungary. Institute of Ecology and Botany, Hungarian Academy of Sciences, Vácrátót, 255 pp.

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

Ecology of Weeds and Invasive Plants: Relationship to Agriculture and Natural Resource Management
https://onlinelibrary.wiley.com/doi/book/10.1002/9780470168943

EPPO Global Database https://gd.eppo.int/

Journals: Weed Research, Weed Science, Biological Invasions

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

The course develops student weed identification competencies and contributes to their understanding of the biological and ecological characteristics of weeds, as well as the processes of plant invasion. In addition, it enhances student communication and cooperation skills through collaborative work carried out during group-based weed diagnostic tasks.

Course Description

Course title / Neptun code: Integrated Weed Management / NVVED100N	Number of credits: 8
Course coordinator (name, position, academic degree): Mihály Zalai, associate professor, PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree): ---	
Course type: compulsory/elective	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: 28 contact hours	
Teaching methods and specific educational tools used for knowledge transfer: case presentations, case-study analyses, project-based learning, discussion of academic papers, science videos.	
Requirements for successful completion: oral exam	
Assessment methods applied for evaluating learning outcomes: oral exam	
Recommended semester: 1-4.	
Prerequisites (if any): --	
Course Description This course introduces students to the development and life cycles of weeds. It provides an overview of the primary methods employed for controlling and managing weeds. Students learn about various strategies for preventing and mitigating weed-related issues. The course also highlights research opportunities related to weeds in their respective fields of study. Overall, the course offers a combination of theoretical knowledge and practical insights into weed management and research.	
Course Topics / Semester Schedule: 1. **Introduction to Integrated Weed Management** – concepts, objectives, principles and importance of integrated approaches to weed control. 2. **Weed Biology and Ecology** – weed life cycles, reproduction, dispersal, dormancy and adaptation to agricultural environments. 3. **Weed Identification and Diagnosis** – identification of major agricultural weeds and assessment of weed infestations. 4. **Weed–Crop Competition** – mechanisms of competition, critical periods of weed interference and effects on crop yield and quality. 5. **Weed Seed Banks and Population Dynamics** – seed production, dormancy, persistence, emergence patterns and factors affecting weed populations. 6. **Cultural Weed Management** – crop rotation, competitive crops, sowing date, crop density and other agronomic practices for suppressing weeds.	

7. **Mechanical and Physical Weed Control** – tillage, hoeing, mowing, mulching and other physical methods of weed management.
8. **Chemical Weed Control** – herbicide groups, modes of action, application principles, selectivity and factors affecting herbicide efficacy.
9. **Herbicide Resistance** – mechanisms, evolution, detection and management of herbicide-resistant weed populations.
10. **Biological Weed Control** – use of natural enemies, pathogens, insects and other biological agents for weed suppression.
11. **Ecological and Preventive Weed Management** – prevention of weed introduction and spread, habitat management and ecological approaches to weed suppression.
12. **Precision Weed Management and New Technologies** – remote sensing, machine vision, robotics, GPS-based applications and site-specific weed control.
13. **Designing Integrated Weed Management Strategies** – combining preventive, cultural, mechanical, biological and chemical methods according to cropping systems and environmental conditions.
14. **Case Studies and Research Perspectives** – evaluation of integrated weed management programmes, analysis of practical examples and identification of current and future research opportunities in weed science.

List of the 2–5 Most Important Required Literature

Publications relating to the students' areas of research. Selected on the basis of the students' research topics.
www.weedscience.org
Lecture materials
Arable Weeds of Hungary. Eds: Novák-Dancza-Szentey-Kamarán. ISBN: 239-99-89-90507-8

List of the 2–5 Most Important Recommended Literature
Weed Science and Weed Management in Rice and Cereal-Based Cropping Systems, Surajit K. De Datta, Aurora M. Baltazar, ISBN (e-book): 978-1-119-73757-5
Weed Research: Expanding Horizons, Eds: Paul E. Hatcher, Robert J. Froud-Williams, ISBN (online): 978-1-119-38070-2
Weed Biology and Management, Ed. Inderjit, ISBN (e-book): 978-94-017-0552-3
Recent Advances in Weed Science, Eds. Bhagirath Singh Chauhan, Gulshan Mahajan, ISBN (e-book): 978-3-031-91014-2

Professional Competences Developed by the Course
Students acquire knowledge of the biology, ecology, development, reproduction and population dynamics of weeds. They understand weed–crop interactions, weed competition, seed banks and the factors influencing weed emergence and persistence. Students also gain knowledge of the principles and methods of weed control, including cultural, mechanical, biological and chemical methods, as well as integrated weed management. Students develop the ability to identify and characterize important weed species and to assess their occurrence and potential impact on crops. They are able to

analyse weed-related problems, evaluate different weed control methods and select appropriate management strategies according to the biological characteristics of weeds, cropping systems and environmental conditions. Students also develop skills in interpreting scientific literature and applying knowledge of weed biology to practical and research-related problems.

Course Description

Course title / Neptun code: Design of experiments and Statistical evaluation	Number of credits: 10
Course coordinator (name, position, academic degree): György Kövér, associate professor, PhD	
Instructor(s) involved in teaching the course, if applicable (name, position, academic degree):	
Course type: compulsory/elective compulsory	
Type of class: lecture/seminar / practical / consultation, and total number of contact hours in the semester: .24/24/48..... contact hours	
Teaching methods and specific educational tools used for knowledge transfer (e.g. case presentations, case-study analyses, project-based learning, other methods): The course is based on case studies with carefully selected datasets	
Requirements for successful completion: Exam	
Assessment methods applied for evaluating learning outcomes: Problem solving in the computer lab	
Recommended semester 1. and 2.	
Prerequisites (if any):	
Course Description Objectives of the course and a concise yet informative description of the knowledge and skills to be acquired.	
This course covers some of the most useful tools of the multivariate statistics. The course focuses on concepts, statistical modeling and practical applications. The students finishing this course will be able to select the suitable statistical method, use the covered software packages, visualize their data and know how to publish their results. This course is based on the usage of the R software package	
Course Topics / Semester Schedule: - Brief coverage of the preliminary studies - Visualization of the multivariate dataset. Histograms, scatter plots, rotating 3D plots - The multivariate normal distribution, the confidence ellipse. - Correlation, covariance and partial correlations - Multiple linear regression. The assumptions of regression. Regression statistics. Regression coefficients, confidence intervals, hypothesis tests. Diagnostic tests. Non-linear fit. Model selection methods. Detecting multicollinearity, heteroscedasticity and autocorrelation.	

- Logistic regression. The odds and odds ratios. The logistic model. Dependent variable. Factors and covariates. Wald statistics. Logistics coefficients and interpretation. Goodness of fit.
- Poisson and quasi Poisson regression. Overdispersion.
- Survival analysis. Cox regression.
- Repeated ANOVA.
- MANOVA
- Principal component analysis. The main objective is data reduction. Eigenvalues, eigenvectors. The interpretation of the principal components. Performing other statistical methods based on the principal components.
- Factor analysis. The factor model. The number of the required factors. The communalities. . The interpretation of the factors. Factor rotation. Factor extraction by principal component, maximum likelihood and principal factor methods. Model assumptions.
- Cluster analysis. Objectives. Measures of distance. Binary variables. Agglomerative and divisive clustering. Cluster description. K-means clustering. Ward method

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Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

List of the 2–5 Most Important Recommended Literature
(textbooks, lecture notes, or other study materials)
Provide complete bibliographic information: author(s), title, publication details, page numbers (if applicable), and ISBN.

McDonald, J.H. 2009. Handbook of Biological Statistics, 2nd ed. Sparky House Publishing, Baltimore, Maryland. http://udel.edu/~mcdonald/statintro.html
Everitt, Brian, Hothorn, Torsten: An Introduction to Applied Multivariate Analysis with R (2011) Springer

Professional Competences Developed by the Course
Please specify the professional competences, competence elements and skills to which the course substantially contributes, including:
Knowledge, Skills, Attitudes, Autonomy and Responsibility

Knowledge
- Knows some of the most useful methods of the multivariate statistics.
- Able to use the R and the STATA software packages.

Skills
- Capable of selecting and applying the proper statistical method

- Capable of evaluating the computational results.
- Capable of creating the required plots to visualize the results.

Attitudes

- Open to understanding and applying further statistical methods.
- Committed to publishing the interpretation and explanation of computational results in an accessible manner

Autonomy and Responsibility

- Independently initiates the uncovering of relationships within the databases.
- Capable of engaging in a professional dialogue on equal terms with representatives of related disciplines and the practical sphere.
- Adheres to ethical research guidelines.