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METHODOLOGY OF PLANT PHYSIOLOGY	
Field (if relevant)	Methodology of Plant Physiology
Specializations	Plant protection, quarantine assessment
Form of delivery	Online and in classroom
Core/Elective	Elective
Course prerequisites (if relevant)	Plant physiology /BSc/
Semester of the course	I, II period
Credit value	4 ECTS
Pass level/grading	Passed (A, B, C, D, E) / Failed (F)
Course language	English
Course Developers	Mongolian University of Life Sciences, Kazkakh National Agrarian Research University.

Course Summary	
This course deals with different plant structures and their functioning. It enables students to analyze physiological processes in plants, namely – photosynthesis, mineral nutrition, respiration, transportation, and ultimately plant development and growth which are traits displayed by living entities. The description is in the context of cellular activities in molecular parameters. It also gives a brief idea of the role of physiological processes in the environment. It covers topics including water, absorption of water, ascent of sap, transpiration, mineral nutrition, fat metabolism, enzymes and plant hormones, plant responses to abiotic and biotic stresses.	
Key terms and notions	
Plant physiology; metabolism; plant cell; photosynthesis; respiration; plant growth and development	
Course aim	
This master course aims to provide the students with detailed introduction to the essential concepts and important physiological aspects related to the functioning of plants as living organisms	
Competencies	
General competencies	-Apply gained knowledge to plan solutions for plant protection issues -Share and obtain information, especially professional knowledge. -Write essays and present to others
Professional competencies	-Use of knowledge in the field of physiology and biochemistry to provide solutions for plant growth and development -Assess the physiological state of agricultural plants and their adaptive potential -Technical and analytical skills to use biological instrumentation and proper laboratory techniques -Teach to others
Learning outcomes	
By the end of this course, students will be able to	
LO1	Explain major concepts in the plant physiological field.

LO2	Describe the main relationship between structure and function of plant organism at all levels: molecular, cellular, and organismal.
LO3	Explain molecular mechanisms responsible for plant reaction to abiotic and biotic stresses- drought, salinity, frost, fungi, insects etc.
LO4	Perform plant physiology experiments
LO5	Apply knowledge to plant breeding, plant protection, precision farming
LO6	Explain and analyze the practical importance of plant development

Content, learning objectives, and learning outcomes in modules/units						
Topic/Content	**Asynchronous**	**Synchronous**	**Independent work**	**Asynchronous theoretical component**	**Synchronous Practical component**	**Module/Unit Learning Outcomes**
Module/Unit 1. [Transport and Translocation of Water and Solute]						
1**.** Water and plant cells	4	2	4	Presentation of plant cell walls, internal hydrostatic pressures, water balance.	Determination of the osmotic potential and water potential of any given plant material (experiment)	List the cell organelles that are externally bounded by a single membrane or a double or paired membrane. List the various functions attributed to proteins embedded in the membrane. Explain the terms diffusion, chemical potential and water potential.
2. Water balance of plants	4	2	4	Presentation of the functions of absorption, translocation and transpiration of water	Determination of the percentage of leaf area open through stomata (experiment)	Explain mechanisms and driving forces operating on water transport within the plant and its environment.

3. Mineral nutrition	4	2	4	Explanation of terms like the apparent free space, Channel proteins8 Electrogenic pump, Facilitated, diffusion, Hydroponic culture, Hyperaccumulators, Macronutrients, Micronutrients, Nutrient film technique, Osmoregulation, Salt respiration, Transmembrane potential	Clarification of difficult concepts and misunderstandings related to material provided asynchronously, apply different techniques used in nutritional studies.	Explain how do plants obtain and use mineral nutrients.
Total for Module/Unit 1	Topics: 3 Asynchronous: 12 Synchronous: 6 Independent work: 12					
Module/Unit 2. [Biochemistry and Metabolism]						
4. Photosynthesis: The light reactions Carbon reactions	4	2	4	Explanation of the concepts of Metabolism, Photosynthesis	Execution of an experiment to demonstrate that CO2, water, light and chlorophyll are essential for photosynthesis (Moll's half-leaf experiment)	Define the role of light in photosynthesis and the structure of photosynthesis. Describe the main storage forms of carbohydrates in plants.
5. Respiration	4	2	4	Explanation of glycolysis, the oxidative decarboxylation of pyruvate to acetyl CoA, the Krebs cycle (citric acid cycle) and the electron transport system	Students will be given review questions and answer.	Outline the three steps involved in the Krebs cycle and the biochemical steps in aerobic respiration where CO_2 molecules are generated.
6. Nitrogen Metabolism	4	2	4	Presentation of Nitrate, Ammonium Assimilation, Amino Acids Protein, Nucleic Acids and Their Structure, Molecular nitrogen Fixation	Students will be given review questions and answer.	Draw a diagrammatic of nitrogen assimilation and Amino Acids Protein, Nucleic Acid structures, and protein synthesis.

7. Lipid Metabolism and Translocation in the Phloem	4	2	4	Explanation of the pathways of lipid biosynthesis that lead to the accumulation of fats and oils, which many plants use for storage. Discussion of the catabolic pathways involved in the breakdown of lipids and the conservation of the degradation products to saccharides that occurs during seeds germination.	Check in with students and clarify difficult concepts and misunderstandings related to material provided asynchronously. Execute an experiment to test the presence of fats in the given plant material	Calculate the number of ATPs produced during lipid metabolism. Name the sites where fatty acids and fats are synthesized
8. The physiological role of macro and Micronutrients, and their assimilation in plants.	4	2	4	Presentation of macroelements and microelements, their physiological role. Physiological disorders with a lack of individual elements.	Students will be given papers to read and answer questions.	Explain the method on the paper.
9. Secondary metabolites	4	2	4	Presentation of the classification, function, and structure of secondary metabolites.	Conduct an essay on the following: chemistry of the second metabolites, pathways of secondary metabolites synthesis in plants, function, and structure of secondary metabolites	Explain how secondary metabolites defend plants against a variety of herbivores and pathogenic microbes.
Total for Module/Unit 2	Topics: 6 Asynchronous: 24 Synchronous: 12 Independent work: 24					
Module/Unit 3 [Growth and development]						
10. Growth and development (Growth hormone)	4	2	4	Presentation of the concept of plant development. Explain that growth, cell differentiation, and pattern formation are regulated at the cellular, biochemical, and molecular levels. Presentation of the morphological, physiological and metabolic features of the stages of ontogeny. Presentation of plant dormancy.	Students will be given review questions and answer and give a speech.	Explain plant growth phases. Draw scheme of sequential steps taking place during the plant development, seed germination, dormancy.

11. Stress physiology	4	2	5	Brief review of the basic principles of plant physiology, thermodynamics, temperature, and its effects on the growth and development of crop and horticultural plants.	Conducting a laboratory experiment (drought stress, salt stress and disease stress)	Compare and contrast mechanisms of plant response to heat, chilling, and freezing stress including injury, acclimation, protection, and resistance.
12. Plant resistance to pathogens.	4	2	3	Providing basic information about plant immunity and physiology of a diseased plant.	Conduct an essay on types of immunity, plant resistance mechanisms	List the main diseases of the most important agricultural crops, and types and mechanisms of plant immunity
Total for Module/Unit 3	Topics: 3 Asynchronous:12 Synchronous: 6 Independent work:12					
Total for the course	**Modules: 3** **Topics: 12** **Asynchronous: 48** **Synchronous: 24** **Independent work: 48**					

	Course learning outcomes	Learning types and teaching methods	Assessment methods
LO1	Explain major concepts in the plant physiological field.	Lecture-based learning Inquiry-based learning	Class participation and preparing for discussions
LO2	Describe the main relationship between structure and function of plant organism at all levels: molecular, cellular, and organismal.	Group learning Technology-based learning	Class participation and preparing for discussions
LO3	Explain molecular mechanisms responsible for plant reaction to abiotic and biotic stresses- drought, salinity, frost, fungi, insects etc.	Expeditionary learning Differentiated instruction	A score of the quiz's assignments
LO4	Perform plant physiology experiments	Group learning Individual learning Laboratory-based learning (Laboratory work)	Class participation and preparedness for discussions
LO5	Apply the knowledge to plant breeding, plant protection, precision farming	Inquiry-based learning Project-based Learning	Quality and integrity of answers on questions and individual presentations
LO6	Explain and analyse the practical importance of plant development	Game-based learning Group learning	Direct Indirect

Assessment scale			
Assessment scale	Mark on the scale of the higher education institution		
	90 – 100	A	passed
	80 – 89.9	B	
	70 – 79.9	C	
	60 – 69.9	D	
	0-59	F	failed

Equipment, digital tools, and educational technologies for the course	
Video and audio recordings, Computers, Google Classroom, Zoom meetings, and the Laboratory of Stress Physiology	
Books and resources recommended for this course	
Essential Reading	1. Plant Physiology, Lincoln Taiz, Eduardo Zeiger, 5 rd edition, 2010. 2. S. L. Kochhar and Sukhbir Kaur Gujral 2020. Plant Physiology Theory and Applicationsь 2nd Edition 3. Plants and Microclimate, Hamlyn G. Jones, Third edition, 2014. 4. Introduction to Plant Physiology, William G.Hopkins and Norman P.A.Huner, 2008.
Recommended Reading	1. Plant Physiology, Mary Duca, 2015. 2. Plant Physiology experimental protocols, Tami Nadu Agricultural institute. 3. Handbook of crop physiology Pessarakli M, Dekker, 2002. 4. Plant Physiology, development, and Metabolism, Satish C. Bhatla, Manju A. Lal, 2018.
Internet resources	1. Biochemistry and Molecular Biology of Plants. 2002. Bob Buchanan, Wilhelm Gruissem, and Russell Jones. Wiley. ISBN-13: 978-0943088396. ISBN-10: 0943088399. 2. Plant Physiology and Development. 2014. 6th edition. Lincoln Taiz, Eduardo Zeiger, Ian Moller, and Angus Murphy. Sinauer Associates, Inc. ISBN-13: 978-0878938667, ISBN-10: 0878938664. 3. Plant hormones, Peter J. Davies,
Course quality monitoring	
End of the semester, the Office of Academic Affairs of the Graduate School will get the questionnaire from master students.	

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IMPROvE_AGRO Erasmus+

Project Erasmus+ Internationalizing Master Programmes in Agriculture via English Medium Instruction (IMPROvE _AGRO)

FIELD EXPERIMENTAL METHODS AND STATISTSICAL ANALYSIS	
Field (if relevant)	Field experimental method and statistical analysis, ARG701
Specializations	Agriculture & Plant protection
Form of delivery	Mixed with online and classroom
Core/Elective	Core
Course prerequisites (if relevant)	None
Semester of the course	I
Credit value	4 ECTS
Pass level/grading	Passed (A, B, C, D, E) / Failed (F)
Course language	English
Course Developers	Mongolian University of Life Sciences

Course summary
During this course the students will learn methods to identify and solve problems, to make research questions and assumptions, plan field research activities correctly, design field research methodologies, conduct observational and experimental research in accordance with the methodology, collect and analyze data, interpret, and present the results. This course introduces students to the basic properties of plant pathogenic viruses, as well as the respective methods of diagnosis, prevention, and control of viral plant diseases. The course, taught in English, employs Content and Language Integrated Learning (CLIL) and English Medium Instruction (EMI) methodology intended for integrated learning of both content and language. The course has been developed within the international Erasmus+ project "Project Erasmus+ 609563-EPP-1 -2019-1-DE-EPPKA2-CBHEJP 'lnternationalizing Master Programmes in Agriculture via English Medium instruction (IMPROvE _AGRO)"
Key terms and notions
Observation; hypothesis; field experiment; experimental design; data analysis; descriptive statistics; inferential statistics;
Course aim
The aim of this course is to support students on designing and implementing their study by field experimentation, to acquire knowledge and skills to develop experimental research methodology, perform experiments in accordance with the methodology, collect and analyze data in proper way and evaluate the results in Crop and Plant protection science.
Competencies

General competencies	Carry out field experiments, process results, Write research proposal, report, draw conclusions, in English Work in teams. Apply researcher ethics, logical thinking, computer skills
Professional competencies	Select topics of research, make scientific hypotheses, develop methodologies, perform experiments, perform statistical analyses, and make decisions based on scientifically grounded conclusions. Review, compare, and consult other researchers' research materials.

Learning outcomes

By the end of this course, students will be able to	
LO1	Choose research topics, formulate their own research question, and hypothesis
LO2	Develop an appropriate experimental design
LO3	Implement the research
LO4	Analyze data
LO5	Interpret and report the results in English

Content, learning objectives, learning outcomes in modules/units						
Topic/Content	**asynchronous**	**synchronous**	**Independent work**	**Asynchronous. theoretical component**	**Synchronous Practical component**	**Module/Unit Learning Outcomes**
Module/Unit 1 [Field experimental methods]						
1. Methods and methodologies of sceintific research	2	2	6	Presentation of scientific research methods and techniques	Explanation of scientific research methods and methodologies, techniques and the ways to apply them (reading papers)	Distinguish scientific research methods and methodologies, Compare techniques in different paper and interpret when and how to use them
2. General understanding of field experiments and planning	2	2	6	Presentation of the types of agronomic experiments, and essentials for field experiment planning	Discussing field experimental planning, experimental hypotheses, topic selection, and field testing using a case study	Describe principles of making test hypotheses, selecting topics, and testing them in field experiments
3. Basic elements of field experimental methods	2	3	5	Presentation of experimental unit, treatment, replication, factors and relevant variables to identify	Identification of experimental unit, treatment, replication, factors and variables using case studies.	Plan a field experiment
4. Methods for selection and measurement of field experimental sites	2	3	5	Presentation of the ways to select and measure the experimental plots	Explanation how to select and measure the experimental plots with specific examples	Demonstrate how to select and measure the experimental plots
5. Experimental design of the field study	2	3	5	Presentation of the basic principles of Experimental design, types of	Presentation of schematic representations of field experiments.	Draw schematic representation of the field experiment.

				experimental design. Schematic representation	Practice single- and multi-factor experimental design	Develop a single- and multi-factor test scheme
6. Observations and measurements at the experimental site	2	3	5	Presentation of the parameters to be observed and measured in experimental plants. Introduction into the methods of harvesting experimental crops, determining the yield, yield structure and yield quality	Work and discussion on the observations and measurements of the experimental plants. Work on examples that describe the yield and structure and quality of some crops	Select parameters and their units, equipment to be observed and measured in the experimental plants. Use the methods of harvesting test crops, determining the yield, yield structure and yield quality
Total for Module/Unit 1	Topics: 6 Asynchronous: 12 Synchronous: 16 Independent work: 32					
Module/Unit 2 [Statistical analysis]						
7. Data exploration and descriptive statistics.	2	2	6	Explanation of descriptive statistics and Schematic presentation of the ways to choose the best adjusted data analysis	Work on examples of descriptive statistics, discussion on the use of statistical application and work on examples of given data	Do descriptive statistics on their collected data and choose proper statistical methods
8. T test	2	2	6	Presentation of statistical hypothesis, types of errors, normal distribution, sum of squares degrees of freedom	Work on two treatment one factor examples	Group a given variation by factor or response variable and perform T test
9. One way and Two way ANOVA	2	2	6	Explanation of the experimental treatments, units, and factors, pseudo and true replication	Work on more than two treatment and one factor examples	Perform One way ANOVA and Two way ANOVA
10. Multivariate analyses	2	2	6	Presentation of independent and dependent variables, Data Reduction Data Interpretation, Cluster analysis, Multidimensional Scaling	Work on multi factor treatment examples	Explain results of multivariate analyses
11. Correlation and Regression analysis	2	2	6	Presentation of correlation coefficient and regression equations and their applications	Work on samples of Correlation and Regression analysis	Perform Correlation and Regression analysis
12. Explaining statistical results	2	2	6	Presentation of F value, p value, statistical significance, mean squares, sum of squares	Execution of some statistical analysis and interpretation of results. Review of a paper and explanation of the results	Interpreter research results
Total for Module/Unit 2	Topics: 6 Asynchronous: 12 Synchronous: 12 Independent work: 36					

Total for the course	**Modules: 2** **Topics: 12** **Asynchronous: 24** **Synchronous: 28** **Independent work: 68**

	Course learning outcomes	Learning types and teaching methods	Assessment methods
LO1	Choose research topics, formulate their own research question, and hypothesis	Read articles, master's theses and discuss at classroom Write summaries and make citations at home Divide into groups, select research topics, make research hypotheses that can be tested in the shortest possible time	Check for summaries and citations. Check that the test hypotheses are possible to be tested and that the rationale is correct
LO2	Develop an appropriate experimental design	Draw and explain diagrams	Evaluate site schemes taking into account the impact of factors, plot size, and correct placement of treatment units
LO3	Implement the research	Explain how to select and measure the experimental plots with specific examples	Demonstrate how to select and measure the experimental plots. Evaluate whether the parameters, their characteristics, methods of measurement, units, etc. are correctly defined
LO4	Analyze data	Teach different statistical methods	Check how students perform the statistical analysis
LO5	Interpret and report the results in English	Explain the statistical processing and results Compare research results, make discussion and conclusions. Prepare presentation	Power point presentation

Assessment scale			
Assessment scale	Mark on the scale of the higher education institution		
	90 – 100	A	passed
	80 – 89.9	B	
	70 – 79.9	C	
	60 – 69.9	D	
	0-59.9	F	failed

Equipment, digital tools, and educational technologies for the course	
Video, audio recordings Plant pictures Google Classroom Computers Statistical Programs	
Books and resources recommended for this course	
Essential Reading	Dospekhov B.A. “Field Experiment Methods” (Б.А.Доспехов “Методика полевого опыта”) Avaadorj D. “Fundamentals methodology of field experiments” Bluman, A.G., 2009. Elementary statistics: A step by step approach. New York, NY: McGraw-Hill Higher Education. Dytham, C., 2011. Choosing and using statistics: a biologist's guide. John Wiley & Sons. Jadambaa B., Chimedlham Ts. 2011. Research methodology Batbold T., Ariunaa D., Bayarmaa B., Battsetseg S., Zol-Erdene D.2018 Research methodology: textbook
Recommended Reading	Gerry P. Quinn, Micheal J.Keough 2002. Experimental Design and data Analysis for Biologists (Third Edition Cambridge University) Kumar, Ranjit 2019. Research Methodology: A Step-by-Step Guide for Beginners Ichinhorloo Sh.2009. Basics of research work
Internet resources	//www.invasiber.org/GarciaBerthou/teaching/statistical-links/
Course quality monitoring	
Test and Questionnaire	

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Course Name: Research Methodology of Crop Science	
Field (if relevant)	Plant protection, Agronomy
Specializations	Plant protection & horticulture
Form of delivery	online & classroom
Core/Elective	Core
Course prerequisites (if relevant)	Crop Science/Horticulture
Semester of the course	Autumn/1
Credit value	4 ECTS
Pass level/grading	Passed (A, B, C, D, E) / Failed (F)
Course language	English
Course Developers	Mongolian University of Life Sciences, Torayghyrov Pavlodar State University (Kaz)

Course Summary

This course is designed to equip students with advanced knowledge and practical skills required to conduct high-quality research in the field of crop sciences.
This course introduces students to the basic properties of plant pathogenic viruses, as well as the respective methods of diagnosis, prevention, and control of viral plant diseases. The course, taught in English, employs Content and Language Integrated Learning (CLIL) and English Medium Instruction

(EMI) methodology intended for integrated learning of both content and language. The course has been developed within the international Erasmus+ project "Project Erasmus+ 609563-EPP-1 -2019-1-DE-EPPKA2-CBHEJP 'lnternationalizing Master Programmes in Agriculture via English Medium instruction (IMPROvE _AGRO)"
Key terms and notions
Plant growth, research methodology of crops, observation, measurement of organ, data collection.
Course aim
This course will provide students with a comprehensive understanding of various research methodologies, techniques, and tools that are utilized to investigate and address key challenges in crop production, management, and improvement.

Competencies	
General competencies	Understand the scientific methods and their application in crop research and apply research questions, hypotheses, and objectives.
Professional competencies	Select methods, make scientific hypotheses, develop methodologies, perform experiments, perform analyses, and make decisions based on scientifically grounded conclusions, organizing and managing data.

Learning outcomes	
By the end of this course, students will be able to	
LO1	Identify research methods for specific crop sciences studies, considering factors such as research objectives, variables, and practical constraints.
LO2	Select and justify appropriate research methods for specific crop sciences studies, considering factors such as research objectives, variables, and practical constraints.

LO3	Demonstrate the ability of field studies, surveys, or case studies that align with research questions and contribute meaningfully to the field of crop sciences.
LO4	Analyze experimental data, interpret results, and make informed conclusions.

Content, learning objectives, and learning outcomes in modules/units						
Topic/Content	**Asynchronous**	**Synchronous**	**Indep. Work**	**Asynchronous. Theoretical component**	**Synchronous Practical component**	**Module/Unit Learning Outcomes**
Module 1						
/Unit 1. (Cereal crops) Research methodology and cultivation technology of cereal crops	1	2	4	Teach the research methods and growing technology of crops	Aspects and theoretical foundations of research methodology of crop science	Select and apply research methods and growth technology on cereal crops
/Unit 2. (Cereal crops) Doing observation of growth stage of cereal crops	1	2	4	To learn methods of measuring and marking growth of cereal crops.	To understand and recognize the importance of studying the stages of growth and development of cereal crops and using for research	Know the recognize the importance of studying the stages of growth and development of cereal crops and using for research
/Unit 3. (Cereal crops) Doing measurement of cereal crops	1	2	5	To teach identify and compare various research methods used in agricultural sciences, emphasizing their applications in cereal crop measurement. Evaluate the distinctions between research methods and research methodologies, highlighting their roles in	To understand and recognize the in cereal crop measurement.	Know the recognize the in cereal crop measurement.

				designing experiments and collecting data.		
/Unit 4. (Cereal crops) Calculating yield and quality of cereal crops	1	2	5	To calculate yield and quality of cereal crops	Visiting the virtual field, determining the growth, keeping an observation journal, analyzing the process	Calculate the yield and quality of cereal crops
Total for Module/Unit 1	Asynchronous: 4 Synchronous:8 Independent work:18					
Module 2						
Unit 5. (Vegetables) Research methodology and cultivation technology of vegetables	1	2	4	Teach the define and explain the basic principles of research methodology as it applies to the cultivation of vegetable crops.	Define and explain the basic principles of research methodology as it applies to the cultivation of vegetable crops	Know the basics of general technologies for growing vegetables
Unit 6. (Vegetables) Do observation of growth stage of vegetables	1	2	4	Teach the identify and define the key growth stages of common vegetables.	Explore the physiological changes that occur during each growth stage	To know the growth stages and observations of various vegetables
Unit 7. (Vegetables) 1. Do measurement of vegetables	1	2	5	Teach the measurement techniques applicable to different types of vegetables. Impart the knowledge familiarity with specialized measurement instruments used in the field of vegetable measurement, and understand their functions and applications.	Measurement techniques applicable to different types of vegetables.	Record the growth of vegetative organs of vegetables
Unit 8. (Vegetables) Calculating yield and quality of vegetables	1	2	5	Teach the define and explain the concept of yield in vegetable production and	Do practical exercises to calculate yields based on real situations. Discuss yield	Understand the determination of yield

				identify key factors influencing yield, such as planting density, fertilization, and irrigation.	estimation challenges and possible solutions.	quantity and quality of vegetable crops
Total for Module 1-2 /Unit 8	Asynchronous: 4 Synchronous:8 Independent work:18					
Module 3						
Unit 9. (Fruits) Research methodology and cultivation technology of fruits	1	2	4	To learn the research methods and growing technology of fruits	Visiting the virtual field, to create a research proposal and to do case study	Select and apply research methods and growing technology of fruits
Unit 10. (Fruits) Do observation of growth stage of fruits	1	2	4	Investigate growth stages of fruits and to learn how to keep an observation journal	Visiting the virtual field, determining the stages, keeping an observation journal, and processing the data	Determine the growth stages of fruits
Unit 11. (Fruits) Do measurement of fruits	1	2	5	To learn methods of measuring and marking growth of fruits	Visiting the virtual field, determining the growth, analyzing the process	Record the growth the vegetative organs of fruits
Unit 12. (Fruits) Calculating yield and quality of fruits	1	2	5	To calculate yield and quality of fruits	Visiting the virtual field, determining the growth, keeping an observation journal, analyzing the process	Examine the yield and quality of fruits
Total for Module/Unit 2	Asynchronous: 4 Synchronous:8 Independent work:18					
Module 4						
Unit 13 (Technical and oil crops) Research methodology and cultivation technology of technical and oil crops	1	2	4	To learn the research methods and growing technology of technical and oil crops	Visiting the virtual field, to create a research proposal and to do case study	Select and apply research methods and growing technology of industrial and oil crops

Unit 14 (Technical and oil crops) Do observation of growth stage of technical and oil crops	1	2	4	Investigate growth stages of technical and oil crops and to learn how to keep an observation journal	Visiting the virtual field, determining the stages, keeping an observation journal, and processing the data	Determine the growth stages of industrial and oil crops
Unit 15 (Technical and oil crops) Do measurement of v technical and oil crops	1	2	5	To learn methods of measuring and marking growth of technical and oil crops.	Visiting the virtual field, determining the growth, analyzing the process	Record the growth of vegetative organs of industrial and oil crops
Unit 16 (Technical and oil crops) Calculating yield and quality of technical and oil crops	1	2	5	To calculate yield and quality of technical and oil crops	Visiting the virtual field, determining the growth, keeping an observation journal, analyzing the process	Examine the yield and quality of industrial and oil crops
Total for Module 3-4 /Unit 9-16	Asynchronous: 4 Synchronous:8 Independent work:18 **Total hours:120**					

	Course learning outcomes	**Learning Types and teaching methods**	**Assessment methods**
LO1	Identify research methods for specific crop sciences studies, considering factors such as research objectives, variables, and practical constraints.	Literature review – Papers review - Discuss in groups	Class participation, creative and active contribution to discussion
LO2	Select and justify appropriate research methods for specific crop sciences studies, considering factors such as research objectives, variables, and practical constraints.	- Discuss in groups	Class participation, creative and active contribution to discussion
LO3	Demonstrate the ability of field studies, surveys, or case studies that align with research questions and contribute meaningfully to the field of crop sciences.	Video presentations – Papers review - Discuss in groups	Individual review of notes and measurement results

LO4	Analyze experimental data, interpret results, and make informed conclusions.	Video presentations – Papers review - Discuss in groups	Individual review of notes and measurement results

Assessment scale			
Assessment scale	Mark on the scale of the higher education institution		
	90 – 100	A	Passed
	80 – 89	B	
	70 – 79	C	
	60 – 69	D	
	0-59	F	Failed

Equipment, digital tools, and educational technologies for the course	
Virtual field and laboratory, laptop, calculator, research tools,	
Books and resources recommended for this course	
Essential Reading	Dospekhov B.A Field experiment methodology Avaadorj D Fundamental methodology field experiment, 1990 Belozerskii.A.H A Practical Guide to Plant Biochemistry, UB, 2000 Avdai.Ch; Enkhtuya D - Research and analysis methodology), UB, 2000
Recommended Reading	1.SS Rana Sr Scientist, Suresh Kumar Principal Scientist" Research Techniques in Agronomy", Department of Agronomy, Forages and Grassland Management College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176062 (India) 2.H.g. Zandstra, e.c. Price, j. A. Litsinger, and r. A. Morris "A methodology for on-farm cropping systems research, 1981, Manila, Philippines 3.Dosfikhov "Research methodology of field" and etc.
Internet resources	Handbook on crop statistics: improving methods for measuring crop area, production and yield
Course quality monitoring	
Test and Questionnaire	

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IMPROvE_AGRO Erasmus+

Project Erasmus+ Internationalizing Master Programmes in Agriculture via English Medium Instruction (IMPROvE _AGRO)

SUSTAINABLE NATURAL RESOURCE MANAGEMENT	
Field (if relevant)	Natural Resources and Sustainability
Specializations	Agriculture & Forestry/ Discipline 4
Form of delivery	Mixed with online and classroom
Core/Elective	Introductory course
Course prerequisites (if relevant)	None
Semester of the course	I
Credit value	4 ECTS
Pass level/grading	Passed (A, B, C, D, E) / Failed (F)
Course language	English
Course Developers	Aristotle University Thessaloniki, Mongolian University of Life Sciences

Course summary
This is an introductory and comprehensive course focusing on specific topics related to sustainable resource management. This course is designed to provide students with a comprehensive understanding of sustainable natural resource management, with a specific emphasis on soil, water, and energy resources in the fields of agriculture and forestry. It integrates principles of environmental protection, conservation, and resource management to address the complex challenges in the context of sustainability. The course, is taught in English, employs Content and Language Integrated Learning (CLIL) and English Medium Instruction (EMI) methodology intended for integrated learning of both content and language. The course has been developed within the international Erasmus+ project "Project Erasmus+ 609563-EPP-1 -2019-1-DE-EPPKA2-CBHEJP 'lnternationalizing Master Programmes in Agriculture via English Medium instruction (IMPROvE _AGRO)"
Key terms and notions
Water, Soil, Energy, Sustainability
Course aim
The aim of this course is to combine theoretical knowledge with practical applications to equip students with the skills and understanding necessary to address complex natural resource management issues.
Competencies

General competencies	Carry out field work, process results. Write research proposal, report, and draw conclusions, in English. Work in teams logical thinking, computer skills
Professional competencies	Select topics of research, develop methodologies, and make decisions based on scientifically grounded conclusions. Review, compare, and consult other researchers' research materials.

Learning outcomes
By the end of this course, students will be able to

LO1	Explain the significance of natural resources in the context of sustainability. Identify challenges and threats to resource sustainability.
LO2	Design sustainable water management practices and adaptation measures for climate change.
LO3	Apply best management practices (BMPs) to reduce nutrient runoff, soil erosion and protect ecosystems.
LO4	Apply renewable energy solutions and estimate energy requirements.

Content, learning objectives, learning outcomes in modules/units						
Topic/Content	**asynchronous**	**Synchronous**	**Independent work**	**Asynchronous theoretical component**	**Synchronous Practical component**	**Module/Unit Learning Outcomes**
Module/Unit 1: INTRODUCTION TO NATURAL RESOURCES MANAGEMENT						
1. Introduction to Sustainable Natural Resources Management	2	3	5	Presentations concerning the: Definition and significance of natural resources. Role of natural resources in the agricultural environment The importance of sustainable resource management.	Site Visit to an Agricultural Farm: Arrange a field visit to a local agricultural farm. Ideally, select a farm that practices sustainable agriculture. Students will have the opportunity to observe different aspects of the farm, including crop cultivation, soil management, and water usage.	Explain the significance of soil, water, and energy resources in the context of natural resource management. Describe the basic principles and practices for sustainable soil, water, and energy management.
2. Challenges and Threats to Resource Sustainability	2	3	5	Reading Assignments: Assign students relevant articles, reports, and research papers covering the challenges to resource sustainability in agriculture. 2. Presentations and Video Lectures on:	Conduct a live demonstration of soil testing methods. Explain how soil quality affects crop production and discuss strategies for improving soil health.	Identify and describe major challenges and threats to resource sustainability in agriculture, including but not limited to soil erosion, water scarcity, and climate change..

				Soil Erosion and Degradation Water Scarcity in Agriculture Climate Change and Agriculture Pesticide Use and its Impact.	Use a virtual simulation to demonstrate the challenges of water scarcity in agriculture. Discuss strategies for efficient water use and irrigation techniques. Discuss the impacts of climate change on agriculture and strategies for adaptation.	
Total for Module/Unit 1	Topics: 2 Asynchronous: 4 Synchronous: 6 Independent work: 10					
Module/Unit 2: WATER RESOURCES MANAGEMENT						
3. Water resources management in agriculture and forestry	2	3	5	Presentations concerning the: Essential role of water in crop production, food security, and forestry operations. Calculation of water requirements for crops and forests and the role of irrigation and forest hydrology in fulfilling water requirements.	Discuss with local farmers and foresters about their water management practices and challenges. Calculation of crop water requirements using the ETo method and crop coefficients.	Explain the significance of water resources in the agricultural and forestry sectors. Apply ETo calculation methods and calculate crop water requirements.
4. Sustainable water uses practices and water policy	2	3	5	Presentations and theoretical material concerning: 1. The Significance of water conservation 2. Water use efficiency. 3. Water Policy and Regulations	Discussion on the environmental, social, and economic benefits of efficient water management. Exploration of national and international water policies and their impact on natural resources management.	Analyze the impact of water policies and regulations. Design efficient irrigation systems. Use sustainable water practices.

5. Water Quality and Pollution Control	2	3	5	Presentations and theoretical materials concerning: 1. Parameters for Assessing Water Quality and methods of measurement. 2. Point and Non-Point Sources of Pollution 3. Environmental Impacts and Economic Consequences	Practical exercises in water quality monitoring and sampling techniques. Discuss the impact of agricultural practices on water quality.	Assess water quality in agricultural and forestry systems. Identify potential sources of pollution. Develop pollution mitigation strategies.
6. Climate Resilience and Future Challenges	2	3	5	Presentations and theoretical materials concerning: 1. The Concept of Climate Resilience 2. Climate Change and Its Impacts 3. Climate Adaptation Strategies and Nature-Based Solutions	Discussion on the environmental, social, and economic impact of climate change. Group discussions of the effectiveness of adaptation and mitigation strategies,	Describe the climate crisis and its impact on agriculture and forestry. Assess vulnerability and risks from climate change. Evaluate future challenges and scenarios related to climate change.
Total for Module/Unit 2	Topics: 4 Asynchronous: 8 Synchronous: 12 Independent work: 20					
Module/Unit 3: SOIL RESOURCE MANAGEMENT						
7. Soil Resources in Agriculture and Forestry	2	3	5	Presentations and theoretical materials on: 1. The critical role of soils in food production, biodiversity, and climate regulation. 2. Soil Properties and Classification Systems 3. Sustainable Soil Conservation	Field visits for soil sampling collection and laboratory analysis of soil samples for the determination of soil properties. Discussion of soil conservation practices including no-till farming, crop rotation, and cover cropping.	Collect and analyze soil samples. Describe soil conservation practices.

8. Soil Fertility and Nutrient Management	2	3	5	Presentations and theoretical materials concerning: 1. The understanding of the essential nutrients required for plant growth. 2. The connection between soil fertility and food security. 3. The understanding of organic matter decomposition and humus formation processes.	Examination of real-world case studies showcasing successful soil nutrient management practices.	Analyzing nutrient cycles and soil-plant interaction. Applying best management practices (BMPs) to reduce nutrient runoff, mitigate water pollution, and protect ecosystems.
9. Soil Conservation and Erosion Control	2	3	5	Presentations and theoretical materials concerning: 1. The Importance of Soil Conservation 2. Exploring the physical processes of erosion: detachment, transport, and deposition.	Field visit to local forest areas prone to erosion and soil degradation. Discussion of reforestation strategies and the importance of proper vegetation management.	Assess soil erosion risk. Select and apply soil erosion control methods.
Total for Module/Unit 3	Topics: 3 Asynchronous: 6 Synchronous: 9 Independent work: 15					
Module/Unit 4: ENERGY MANAGEMENT						
10. Introduction to Energy Use in Agriculture and Forestry	2	3	5	Presentations and theoretical matters concerning: 1. The critical role of energy in crop production, forest management, and sustainable resource utilization. 2. Types of energy sources.	Identify energy-intensive processes and areas where improvements can be made.	Explain the role of energy in agricultural and forestry systems. Describe the different types of energy.

11. Energy Efficiency and Conservation in Agriculture and Forestry	2	3	5	Presentations and theoretical materials concerning: 1. Overview of the key concepts and objectives. 2. Core principles related to energy efficiency and techniques for reducing energy consumption in irrigation, agricultural operations, and forest management.	Discussion on the role of sustainable practices and technology in reducing energy consumption – examination of real-world case studies.	Identify energy efficiency opportunities. Promote sustainable practices – communicate the importance of sustainable energy management to stakeholders.
12. Renewable Energy in Agricultural and Forestry Operations	2	3	5	Presentations and theoretical materials concerning: 1. Overview of various types of renewable energy, including solar, wind, biomass, and hydropower. 2. Assessment of energy requirements in agricultural and forestry processes.	Field visit to renewable energy installation. Examination of real-world case studies.	Calculate energy requirements. Integrate renewable energy solutions into resource management strategies in agriculture and forestry.
Total for Module/Unit 4	Topics: 3 Asynchronous: 6 Synchronous: 9 Independent work: 15					
Total for the course	**Modules: 4** **Topics: 12** **Asynchronous: 24** **Synchronous: 36** **Independent work:60**					

Assessment scale			
Assessment scale	Mark on the scale of the higher education institution		
	90 – 100	A	Passed
	80 – 89.9	B	
	70 – 79.9	C	
	60 – 69.9	D	
	50 – 59.9	E	
	0- 49	F	Failed

Equipment, digital tools, and educational technologies for the course
Guided video tours of sustainable natural resource management projects can provide real-world context for discussion. **Google Classroom** for sharing documents, assignments, and conducting discussions. **Geographic Information Systems (GIS)**: to analyze spatial data related to natural resources and environmental conservation.

Books and resources recommended for this course	
Essential Reading	Parris, K. (2010). Sustainable management of water resources in agriculture. OECD Publishing. https://www.oecd.org/greengrowth/sustainable-agriculture/49040929.pdf Jayaraman[1] So, Dalal R, Patra Ak, Lal R. (2023) Sustainable Soil Management: Challenges, Prospects And Benefits. Sustainable Soil Management: Beyond Food Production, https://www.cambridgescholars.com/product/978-1-5275-0204-8 Golušin, M., Dodić, S., & Popov, S. (2013). Sustainable energy management (pp. 1-391). Elsevier. https://www.sciencedirect.com/book/9780124159785/sustainable-energy-management
Recommended Reading	Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56. Fao, Rome, 300(9), D05109. Ali, H. (2010). Fundamentals of irrigation and on-farm water management: Volume 1 (Vol. 1). Springer Science & Business Media.

	Gunston, H. (2012). Practices of Irrigation and On-Farm Water Management–Volume 2. By MH Ali. Heidelberg, Germany: Springer (2011), pp. 546 Mirjana, R. (2022). Sustainable Energy Management: Planning, Implementation, Control, and Security. Elsevier Science & Technology https://www.sciencedirect.com/book/9780128210864/sustainable-energy-management
Internet resources	Video: Agriculture and water. What's the issue, and what can policymakers do?, OECD https://www.youtube.com/watch?v=WY2T1jIlFKw Video: Agriculture and climate change. What's the issue, and what can policymakers do?https://www.youtube.com/watch?v=IFte1FUHYFw Video:Sustainable nature resources management in Central Asian countries, FAO, https://www.youtube.com/watch?v=qwVmG_BlS60 Video: The Water-Energy Challenge in Central Asia, World Bank, https://www.youtube.com/watch?v=wMtdByx9mm0
Course quality monitoring	
Students' evaluation Questionnaire	