University of Zagreb Faculty of Agriculture
Svetosimunska street 25, 10000 Zagreb, Croatia
Contact: harissa@agr.hr
www.agr.hr

BOOK OF SYLLABUS FOR INTERNATIONAL JOINT PhD PROGRAM IN "PLANT HEALTH IN SUSTAINABLE AGRICULTURE" (PHiSA)

Table of Contents

University of Zagreb Faculty of Agriculture
Svetosimunska street 25, 10000 Zagreb, Croatia
Contact: harissa@agr.hr
www.agr.hr

Learning outcomes of the PhD study program

1. Demonstrate the mastery of skills to critically apply range of existing theories, methods, and tools for ensuring plant health in sustainable agriculture
2. Demonstrate the ability to conceive, design and conduct research and publish the results in high-ranking journals with the aim of disseminating new knowledge and to apply new knowledge and skills
3. Critically analyze and evaluate the results of its own scientific research, interpret, and argue against larger and more complex social groups and present the latest technical, technological, and socio-economic knowledge in the field of plant health in sustainable agriculture
4. Actively participate in the preparation of studies, project proposals, strategic and operational documents in the field of plant health in sustainable agriculture
5. Create new proposals (individually and/or in teams) to solve the problem related to plant health following the principles of sustainability in changing and unknown environmental, productive, economic and socio-political conditions and circumstances
6. Individually suggest and take part in the adoption of measures for agricultural, environmental and rural development policies related to plant health.
7. Follow, synthesize and evaluate national and international scientific and professional literature and to evaluate the scientific and professional work in the field of plant health

Learning outcomes of the focus areas

Focus area 1: Diagnosis in plant health

- Apply various advanced diagnostic methods in plant prejudicial organism detection in relation to their reliability, cost and ease use
- Select, develop, set up and validate the appropriate methods of monitoring of plant materials and soil so as identification methods in order to determine the level of plant prejudicial organisms
- Analyze and identify the reasons for the appearance of certain pathogens and plant feeders
- Design and compare plant protection measures in conventional, integrated and organic agricultural production for their efficiency with regard to environmental impact, and operator and consumer safety

- Explain the principles and evaluate the potentiality of application of precision agriculture in IPM
- Create/design and conduct field and laboratory research in the area of IPM

Focus area 2: Sustainable use of pesticides

- Appraise and revise the most important pesticide properties, efficiency, safety of application, phytotoxicity, resistance, and environmental impact;
- Develop innovative methods in accordance with the comprehensive methods in phytopharmacy
- Predict of pests and disease appearance and assess of their harmfulness, as well as recommend of IPM strategy
- Compare and rate potential impacts and consequences of application of different group of PPPs on agro-ecosystem
- Generate and evaluate new ideas or tactics in system of sustainable use of pesticides.

Focus area 3: Plant feeders

- Judge the importance and analyze morphological and physiological characteristics of plant feeders
- Compare and assess the fundamental principles of plant feeders' phylogeny and systematics
- Discuss and distinguish biological and ecological characteristics of plant feeders
- Argue the molecular mechanisms by which DNA controls development, growth or morphological characteristics of plant feeders, and use of molecular data in pest and resistance management
- Employ, test and design advanced methods of monitoring, collection, identification and damage evaluation of economically important plant feeders
- Predict plant feeders' population size and dynamics based on phenology models
- Interpret the principles of plant feeders' specific adaptations and evaluate host plant resistance mechanisms.
- Assess and develop a pest and resistance management plan based on a modern and sustainable approach which implies a sustainability and preservation of biodiversity
- Formulate major pest damage thresholds, develop surveillance programs and risk maps for major pests and invasive species

University of Zagreb Faculty of Agriculture
Svetosimunska street 25, 10000 Zagreb, Croatia
Contact: harissa@agr.hr
www.agr.hr

Focus area 4: Plant pathology

- Recognize & differentiate between plant pathogens
- Formulate scientific hypothesis on plant pathology for disease resistance and virulence
- Design disease resistance and pathogenicity experiments based on correct methodology
- Collect Experimental data from in planta experiments
- Rate & Evaluate disease resistance
- Manage and formulate raw data of pathogenicity experiments
- Interpret plant pathology and molecular biology data
- Conclude to scientific results

Focus area 5: Weed science

- Attach weed biology and ecology to sustainable weed management
- Explain weed-crop interaction in agriculture
- Predict weed emergence and develop new methods for weed monitoring and mapping
- Categorize advantages and disadvantages of each weed control method

Focus area 6: Mycotoxins and food safety

- Define the terms food safety, food poisoning, food hazard and mycotoxins
- Identify what might happen if mycotoxin hazards are not controlled
- Recognize the importance of reporting food safety hazards regarding mycotoxins and the importance of implementing procedures to control mycotoxins
- Identify and describe the present worldwide status on mycotoxin contamination in food and feed
- Define and describe the methodology of classical, molecular and chemical identification of mycotoxigenic fungi
- Define and describe mycotoxin risk assessment and the epidemiology of mycotoxigenic fungi at pre- and post-harvest level
- Design experiments based on the epidemiology of mycotoxigenic fungi
- Describe the classical and new methods on the identification of mycotoxins in food and feed
- Describe and analyze mycotoxin prediction modeling at pre- and post-harvest level of food production
- Develop an integrated pest management approach to prevent mycotoxins

- Collect and analyze data from the experimentation on mycotoxins management strategies
- Identify the costs of poor food safety practices to a business

Focus area 7: General contents of transversal interest

- Categorize basic concepts of scientific research: set-up explicable hypothesis, determine the measurable research goals and design original research in the field of plant health for sustainable agriculture
- Critically analyze and evaluate the results of its own scientific research in sense of scientific writing,
- Evaluate bio-indicators of soil health to interpret interaction among soil organisms in order to value biodiversity
- Access appropriate ecological indices in sustainable agriculture
- Interpret and argue the latest technical, technological and socio-economic knowledge related to plant health in the field of sustainable agriculture
- Create and actively participate in the preparation of studies and project proposals in the field of plant health in sustainable agriculture. Value and analyze project calls to find appropriate call to apply for research funding.
- Organize and apply for patent protection at national and international level and manage the intellectual property rights

University of Zagreb Faculty of Agriculture
Svetosimunska street 25, 10000 Zagreb, Croatia
Contact: harissa@agr.hr
www.agr.hr

List of courses

Title	Acronym	ECTS	Status
Focus area 1: Diagnosis in plant health and IPM			
Advanced diagnostic methods and techniques for detection of prejudicial and beneficial organisms	ADM & TDO	4	Elective
Integrated approach to surveillance of prejudicial organisms affecting plant health	IAS	4	Elective
Control of quarantine prejudicial organisms, managing of non-native beneficial organisms and evaluation of risk assessment based on EU protocols	CQPO, MNNB & ERA	3	Elective
Focus area 2: Sustainable use of pesticides			
Plant Protection Products in Sustainable Agriculture	PPPSA	4	Elective
Environmental fate of pesticides	EFP	3	Elective
Toxicology and Ecotoxicology of pesticides	TEP	3	Elective
Focus area 3: Plant feeders			
Advanced techniques in plant feeders	ATPF	3	Elective
Frontiers in invertebrate pest and resistance management	FIPRM	4	Elective
Advanced invertebrate pathology	AIP	3	Elective
Invasive alien pests	IAP	3	Elective
Vectors of plant pathogens	VPP	3	Elective
Integrated Management of urban pests	IMUP	3	Elective
Focus area 4: Plant pathology			
Molecular Plant Microbe Interactions	MPMI	4	Elective
Focus area 5: Weed science			
Weed management in precision agriculture	WMPA	3	Elective
Modelling in Weed Science	MWS	3	Elective
Invasive plant species	IPS	4	Elective
Focus area 6: Mycotoxins and food safety			
Mycotoxins and food safety	MFS	3	Elective
Focus area 7: General contents of transversal interest			
Bio-diversity and bio-indicators in sustainable agriculture	BD & BI	3	Elective
GIS & Spatial Data Analysis	GIS & SDA	3	Elective
Principles of Scientific Work in Bio-science	PSWB	3	Mandatory
Bio-informatics	BINF	3	Mandatory
Knowledge and management of research funding systems	KMRFS	4	Mandatory

University of Zagreb Faculty of Agriculture
Svetosimunska street 25, 10000 Zagreb, Croatia
Contact: harissa@agr.hr
www.agr.hr

Book of Courses

Focus area 1: Diagnosis in plant health

Course title	Advanced diagnostic methods and techniques for detection of prejudicial and beneficial organisms		
Course code	ADM&TDO		
Course leader	Epameinondas Paplomatas (AUA)		
Responsible PI (University/Faculty/Department/Country)	Agricultural University of Athens / Faculty of Crop Science/Department of Phytopathology/Greece (AUA)		
Other teachers and related PIs (University/Faculty/Department/Country)	Stefania Pollastro (UNIBA), Maja Čačija (FAZ), Dimitrios Tsitsigiannis (AUA), Sotiris Tjamos (AUA), Elisavet Chatzivassiliou (AUA), Aliki Tzima (AUA), Dionysios Perdikis (AUA), Ioannis Giannakou (AUA), Jelena Zindovic (UoM), Magdalena Cara (AUT), Dragana Budakov (UNS)		
Credits (ECTS)	**4**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Possession/Advanced of knowledge and skills of selecting adequate application of advanced diagnostic methods and techniques of detection of prejudicial and beneficial organisms. Possession of skills in laboratory and field conditions for applied/professional and research work.		
Learning outcomes	1. Apply various advanced diagnostic methods in plant prejudicial organism detection in relation to their reliability, cost and ease use. 2. Select, develop, set up and validate the appropriate methods of monitoring of plant materials and soil as well as define		

	methods in order to determine the relevance of plant prejudicial organisms. 3. Create/design and conduct field and laboratory research in the area of IPM.

Course content:

Theoretical lessons:

Introduction to the most common and the most advanced/modern diagnostic methods and techniques in detection of prejudicial and beneficial organisms. Their pros and cons in respect to the classical methods and techniques. Molecular and serological methods, LAMP, MALDI-TOF, NGS, DNA barcoding, MLSTs, microarrays, Taqman arrays. Case studies on selected objectives of research/organisms.

Practical lessons:

Applied research work on detection on selected/targeted prejudicial and/or beneficial organisms with appropriate advanced diagnostic methods, depending on the objective. Molecular and serological methods, i.e. LAMP, MALDI-TOF, NGS, DNA barcoding, MLSTs, arrays.

Literature and other learning material:

- Ivan Tsvetkov, Atanas Atanassov, Mariana Vlahova, Lucien Carlier, Nikolai Christov, Francois Lefort, Krasimir Rusanov, Ilian Badjakov, Ivayla Dincheva, Mark Tchamitchian, Goritsa Rakleova, Liliya Georgieva, Lucius Tamm, Anelia Iantcheva, Joelle Herforth-Rahmé, Epaminondas Paplomatas & Ivan Atanassov (2018) Plant organic farming research – current status and opportunities for future development, Biotechnology & Biotechnological Equipment, 32:2, 241-260, DOI: 10.1080/13102818.2018.1427509.
- Antoniou, P.P., Markakis, E.A., Tjamos, S.E. et al. Novel methodologies in screening and selecting olive varieties and root-stocks for resistance to Verticillium dahliae. Eur J Plant Pathol 122, 549–560 (2008). https://doi.org/10.1007/s10658-008-9323-0.
- Paplomatas, E.J. (2004). Molecular diagnostics for soilborne fungal pathogens. Phytopathologia Mediterranea, 43(2), 213-220.
- Termorshuizen AJ, Davis JR, Gort G, Harris DC, Huisman OC, Lazarovits G, Locke T, Melero Vara JM, Mol L, Paplomatas EJ, Platt HW, Powelson M, Rouse DI, Rowe RC, Tsror L. Interlaboratory comparison of methods To quantify microsclerotia of verticillium dahliae in soil. Appl Environ

Microbiol. 1998 Oct;64(10):3846-53. doi: 10.1128/AEM.64.10.3846-3853.1998. PMID: 9758809; PMCID: PMC106567.

Number of classes		
Lectures (theoretical, practical lessons, seminars = contact hours):	**Student research work:** -	**Other activities (preparation for exam, literature research, preparation of seminars etc.):**
30	**-**	**70**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory, seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade is formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title	Integrated approach to surveillance of prejudicial organisms affecting plant health
Course code	IAS
Course leader	Mirha Đikić (UNSA), Karolina Vrandečić (FAZOS)
Responsible PI University/Faculty/Department/Country	UNSA FAZOS
Other teachers and related PIs (University/Faculty/Department/Country)	Ivan Juran (FAZ), Anita Liška (FAZOS), Aleksandra Konjević (UNS), Teofil Gavrić (UNSA), Franco Nigro

		(UNIBA), Igor Pajović (UoM), Milan Ivanović (UB), Mihaela Kavran (UNS), Vera Stojšin (UNS)	
Credits (ECTS)	4	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Acquiring knowledge and understanding of integrated approach to surveillance of prejudicial organisms affecting plant health and its importance for sustainable agriculture and environmental protection: knowledge, skills and competences (know how) for selection and implementation of integral surveillance strategies, protocols, monitoring methods and techniques, perspectives of application of alternative modern control techniques in sustainable agriculture.		
Learning outcomes	1. Select, develop, set up and validate the appropriate methods of monitoring of plant materials and soil as well as define methods in order to determine the relevance of plant prejudicial organisms. 2. Analyze and identify reasons of mass occurrence and spreading of certain plant pathogens, pests and weeds. 3. Design and compare plant protection measures in conventional, integrated and organic agricultural production for their efficiency with regard to environmental impact, and operator and consumer safety. 4. Explain the principles and evaluate the potentiality of application of precision agriculture in IPM. 5. Create/design and conduct field and laboratory research in the area of IPM.		
Course content:			
Theoretical lessons: Integrated pest management approach in sustainable agriculture; protocols for surveillance of plant pathogens, pests, weeds and beneficial organisms; techniques and methods of monitoring and interpretation of monitoring results; preparedness, early detection, signalization for outbreak			

prevention and control of prejudicial organisms; alternative control techniques in sustainable agriculture; case studies on actual topics.

Practical classes: laboratory exercises

Training and application of different monitoring and control methods and techniques; field and laboratory exercises on targeted organisms.

Literature and other learning material:

- Altieri M.A. Nicholls C.I. (2004): Biodiversity and Pest Management in Agroecosystems. Second Edition. Food Products Press, an imprint of The Haworth Press, Inc.236 pp.
- Walter, G. H., (2005): Insect pest management and ecological research. Cambridge University Press. 387 pp.
- Schauff ME (2001) Collecting and preserving insects and mites: techniques and tools. [Updated and modified WWW version of Steyskal GC, Murphy WL, Hoover EH (Eds) (1986) Insects and mites: techniques for collection and preservation.] Agricultural Research Service, USDA, Miscellaneous Publication 1443: 1–103. http://www.ars.usda.gov/SP2UserFiles/ad_hoc/12754100CollectingandPreservingInsectsandMites/collpres.pdf
- Leather, S. R. (2005): Insect Sampling in Forest Ecosystems. Blackwell Science Ltd
- Gibb T.J., Oseto C.Y. (2006): Arthropod Collection and Identification Field and Laboratory Techniques. Elsevier Academic PressAcademic Press, 311 pp.
- Dyck V.A., Hendichs J., Robinson A.S. (2005): Sterile Insect Technique Principles and Practice in Area-Wide Integrated Pest Management. Joint FAO/IAEA Programme, Vienna, Austria. Springer, Netherlands. 787 pp
- Horowitz A.R., Ishaaya I. (2004): Insect Pest Management: Field and Protected Crops. Springer-Verlag Berlin Heidelberg. 344 pp.
- Rechcigl, J. E., Rechcigl N. A. (Eds) (2000): Insect pest management: techniques for environmental protection. Lewis Publishers- an imprint of CRC Press LLC. 408 pp
- Altieri M.A. Nicholls C.I., Fritz M.A. (2005): Manage insects on your farm: a guide to ecological strategies. Sustainable Agriculture Network handbook series; bk. 7, 119 pp.
- Kogan M., Jepson P. (Eds) (2007): Perspectives in ecological theory and integrated pest management. Cambridge University Press, UK, 570 pp

- Horne P.A., Page J. (2008): Integrated pest management for crops and pastures. Landlinks Press, 119 pp.
- Flint M.L., Van den Bosch R. (1981): Introduction to Integrated Pest Management. Plenum Press, New York, 240 pp.
- Aldrich, R.J., Kremer, R.J. (1997). Principled in Weed Management, Iowa State University
- Naylor, R.E.L. (2002). Weed management Handbook. British Crop Protection Council

Number of classes

Lectures (teoretical, practical lessons, seminars = contact hours)	**Student research work:** -	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
30	**-**	**70**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title	Control of quarantine prejudicial organisms, managing of non-native beneficial organisms and evaluation of risk assessment based on EU protocols
Course code	CQPO, MNNB & ERA

Course leaders		Enrico de Lillo (UNIBA), Francesco Porcelli (UNIBA)	
Responsible PI University/Faculty/Department/Country		University of Bari /Department of Soil, Plant and Food Sciences /Italy(UNIBA)	
Other teachers and related PIs (University/Faculty/Department/Country)		Aleksandra Konjević (UNS), Ivana Pajač Živković (FAZ), Ferenc Bagi (UNS), Jasenka Ćosić (FAZOS), Aleksandra Bulajić (UB), Roberta Spanò (UNIBA), Mila Grahovac (UNS)	
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Acquiring advanced knowledge and skills for setting up and developing a control plan of quarantine/alien prejudicial organisms. Acquiring advanced knowledge and skills for setting up and developing a release plan of non-native beneficial organisms. Acquiring advanced knowledge and skills for provide a risk assessment analysis. Acquiring advanced knowledge and skills suitable for the application of phytosanitary measures in quality certification process for agricultural products.		
Learning outcomes	• Analyze and identify the reasons for the appearance of plant pathogens and plant feeders. • Design and compare plant protection measures in conventional, integrated and organic agricultural production for their efficiency with regard to environmental impact, and operator and consumer safety. • Evaluate the risks of introduction and spreading of quarantine organisms, design and apply protocols for		

	prevention of introduction, early detection and surveillance of quarantine organisms. • Evaluate the risks of release of non-native beneficial organisms. • Apply phytosanitary measures for the production and the marketing of propagating plant materials (certification programs).

Course content

Theoretical lessons:

Introduction to the European rules regulating quarantine prejudicial organisms and the introduction of non-native biological control agents. Bio-ethological and epidemiological information needed for developing and applying a control/eradication plan. Bio-ethological information needed for developing a release plan of beneficial organism. Principles of risk assessment analysis. Certification of nursery productions (Objectives, steps, categories and health status of plant materials).

Practical lessons:

Critical evaluation of a case study of the accidental introduction of a quarantine/alien species and how it was controlled (positive and negative cases). Application of a risk assessment analysis with case studies on selected organisms. Application of micropropagation techniques for the production of certified plant material.

Literature and other learning material:

- EPPO Standards. Schemes for the production of healthy plants for planting. 2009 OEPP/EPPO Bulletin 39, 267–270, doi: 10.1111/j.1365-2338.2009.02307.x
- EPPO 2022. EPPO Global Database, https://gd.eppo.int/
- European Commission. 2000. EU plant health legislation. Directive 2000/29/EC. https://ec.europa.eu/food/plants/plant-health-and-biosecurity/legislation_en
- Law on plant health. 2019. *(""Official Gazette RS", No. 41/2009 i 17/2019)*Parris K.M. 2016 - Ecology of Urban Environments. WyleyBlackwell, ISBN: 9781444332643 (Hardback) ISBN: 9781444332650 (Paperback), 224 pp.
- Palm, M.E. 2001 - Systematics and the Impact of Invasive Fungi on Agriculture in the United States: Knowledge of the systematics of plant-inhabiting fungi is fundamental for making appropriate plant quarantine decisions and thereby safeguarding US plant resources.

BioScience, Volume 51, Issue 2, February, Pages 141–147, https://doi.org/10.1641/0006-3568(2001)051[0141:SATIOI]2.0.CO;2

- Partho Dhang (Ed.) 2014 - Urban Insect Pests Sustainable Management Strategies. C.A.B. International, ISBN-13: 978 1 78064 275 8, 249 pp.
- Roques A, Kenis M., Lees D., Lopez-Vaamonde C., RabitschW., Rasplus J.-Y., Roy D.B. (Ed.s) 2010 - Alien terrestrial arthropods of Europe. Special Issue, BioRisk, 4: 1021 pp. http://pensoftonline.net/biorisk

Number of classes (=workload of students)		
Lectures (theoretical and practical lessons, seminars, laboratory, and field activities):	**Student research work:**	**Other activities (preparation for the exam, literature research, preparation of seminars, etc.):**
20 hours		**55 hours**

Teaching methods: PPT presentations, videos and other multimedia tools, demonstrations in field and laboratory, occasional seminars.

Evaluation:

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures	----	**Written exam**	50
Practical classes	----	**Oral exam**	50
Colloquium	---		
Seminar papers	---		

A way to form a final grade:

Final grade - formed based on the sum of acquired points, with the minimum of 26/50 required points for both written and oral exam.

Focus area 2: Sustainable use of pesticides

Course title	Plant Protection Products in Sustainable Agriculture
Course code	PPPSA

Course leader		Slavica Vuković (UNS)	
Responsible PI (University/Faculty/Department/Country)		UNS, AU, FAZ, UNIBA, AUT, UOM	
Other teachers and related PIs (University/Faculty/Department/Country)		Renata Bažok (FAZ); Matteo Spagnuolo (UNIBA); Franco Faretra (UNIBA); Magdalena Cara (AUT); Nedeljko Latinović (UOM)	
Credits (ECTS)	**4**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Ability to work in scientific organizations and teams that deal with the study of the modern methods in the sustainable application of plant protection products. Ability to apply standards and regulations related to the efficient and safe application of plant.		
Learning outcomes	Generate and relate acquired knowledge for planning research activities in the area of modern pesticide application; Devise and evaluate new strategies in terms of providing safe food production and environmental protection; Compare and summarize different methods and techniques for monitoring resistance of harmful organisms to plant protection products; Combine and assess alternative strategies (application of biopesticides and non-pesticide compounds) in the control of pests and diseases in order to create suitable basis for rational and sustainable use of plant protection products.		
Course content:			
Theoretical lessons: Plant protection products legislation. Biological effects of plant protection products on harmful organisms in conventional, integral and organic agriculture. Mode of action of plant protection products. Physical and biological compatibility of pesticide mixtures and/or mixtures of pesticides and non-pesticide compounds. Alternatives to pesticides of high risk. Biopesticides and non-pesticide compounds in phytopharmacy. Changes in pest sensitivity towards plant protection products and			

strategies for its prevention or/and delay.Principles of pesticide resistance management in accordance with the recommendations IRAC, FRAC, HRAC, etc.

Practical lessons:

Effects of plant protection products (efficacy, phytotoxicity). Basic criteria for preparation of pesticide mixtures; Evaluation of sensitivity levels of pest organisms towards plant protection products, analysis and data interpretation; The application of the standard, validated and simple methods for detecting pest resistance to pesticides is crucial for the successful monitoring of resistance problems. Roll and significance of rapid and reliable biological methods i.e. bioassays in phytopharmacy. Statistical analysis of results bioassays

Literature and other learning material :

1. Keith J Brent and Derek W Hollomon (2007): Fungicide resistance:The assessment of risk, Fungicide Resistance Action Committee (https://www.frac.info/docs/defaultsource/publications/monographs/monograph-2.pdf)
2. Hideo Ishii and Derek William Hollomon (2015): Fungicide Resistance in Plant Pathogens, Principles and a Guide to Practical Management.
3. Murad Ghanim and Isaac Ishaaya (2011): Insecticides with Novel Modes of Action Mechanism and Resistance Management (https://www.researchgate.net/publication/272817377_Insecticides_with_Novel_Modes_of_Action_Mechanism_and_Resistance_Management)
4. Hugh J. Beckie (2019): Herbicide Resistance in Plants, Special Issue Published in Plants
5. Senthil-Nathan, Sengottayan (2015): A Review of Biopesticides and Their Mode of Action Against Insect Pests, DOI: 10.1007/978-81-322-2056-5_3 (https://www.researchgate.net/publication/277017477_A_Review_of_Biopesticides_and_Their_Mode_of_Action_Against_Insect_Pests)
6. EPPO Standards, Guidelines for the efficacy evaluation of plant protection products (https://www.eppo.int/RESOURCES/eppo_standards/pm5_pra)
7. Test methods - IRAC (https://irac-online.org/methods/), FRAC (https://www.frac.info/knowledge-database/monitoring-methods), HRAC (https://hracglobal.com/europe/test-methods)
8. National and EU Legislation on plant protection products.

9. Jeschke, P., Witschel, M., Kramer, W., Schirmer, U. (2019): Modern Crop Protection Compounds (Herbicides; Fungicides; Insecticides) 3 rd, Revised and Enlarged Edition, Wiley-VCH Verlag & Co. KgaA, Weinheim, Germany.

Number of classes (=workload of students)

Lectures (teoretical , practical lessons, seminars = contact hours): 30	**Student research work:** -	**Other activities (preparation for exam, literature research, preparation of seminars etc):** 70

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory, seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title	Environmental fate of pesticides
Course code	EFP
Course leader	Matteo Spagnuolo (UNIBA) ;Magdalena Cara (AUT)
Responsible PI (University/Faculty/Department/Country	University of Bari -Department of Soil, Plant and Food Sciences (Italy)
Other teachers and related PIs (University/Faculty/Department/Country)	Dragica Brkić (UB) dragica.brkic@agrif.bg.ac.rs Ivan Ostojić (SVEMO) ivan.ostojic@aptf.sum.ba Sanja Lazić (UNS) sanjal@polj.uns.ac.rs

Credits (ECTS)	3	Course status	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Ability to apply the legislation on the use and commercialization of plant protection products The student will acquire analytical and problem solving skills to indepentently face different technical situations in terms of reducing the environmental impact of pesticides		
Learning outcomes	Appraise and revise the environmental impact of pesticides; Develop innovative management practices for reducing the environmental impact of pesticides; Plan and recommend the pesticide risk assessment; Generate and evaluate new ideas or strategies for action plans in the sustainable use of pesticides. Estimate and interpret environmental fate of pesticides.		
Course content:			
Theoretical lessons: Fate of pesticides in in the atmosphere, water and soil. Diffuse and point source contamination of pesticides. Legislation on the Sustainable use of pesticides and statistics on pesticides use. The legislation on priority substances (pesticides) under the Water Framework Directive (WFD). Diffusion, volatilization and mass transfer. Transport and accumulation of pesticides in plant. Influence of physical-chemical properties on the absorption and translocation of pesticides in plant. Methabolism of pesticides in plant. Detoxification reactions: red-ox, hydrolysis, coniugation, role of glutathione, glucose and amino acids. Photodegradation of pesticides Adsorption of pesticides in soil. Transformation: persistence, chemical degradation, microbial and enzymatic degradation of pesticides in soil. Effects of climate and management, and their interactions on pesticide losses.			

Pesticide evaluation: Tools and Pesticide fate models FOCUS, etc. Creation of maps using GIS.

Chemical and biotechnological processes of soil remediation.

Best Management Practices (BMP's) to reduce soil, water and atmosphere contamination of pesticides

Practical lessons:

Sorption isotherms of pesticides in soil.

Analytical methods for the determination of pesticide residues in soil and water.

Risk analysis for soil contaminated by pesticides: bioavailability and bioaccessibility assessment with different organisms. Pesticide fate models.

Estimation of environmental stress effects of Pesticide Mixtures on Daphnia magna.

Mesocosmos & aquatic biomonitoring- and assessment studies according to the WFD: algae, macrophytes, zooplankton, macroinvertebrates, physical and chemical water parameters.

Literature and other learning material:

1. De Wilde, T., Spanoghe, P., Debaer, C., Ryckeboer, J., Springael, D., Jaeken, P. (2007). Overview of on-farm bioremediation systems to reduce the occurrence of point source contamination. Pest Management Science, 63 (2), pp. 111-128. DOI: 10.1002/ps.1323
2. Karanasios, E., Tsiropoulos, N.G., Karpouzas, D.G. (2012).On-farm biopurification systems for the depuration of pesticide wastewaters: Recent biotechnological advances and future perspectives. Biodegradation, 23 (6), pp. 787-802. DOI: 10.1007/s10532-012-9571-8
3. Peña, A., Delgado-Moreno, L., Rodríguez-Liébana, J.A. (2020) A review of the impact of wastewater on the fate of pesticides in soils: Effect of some soil and solution properties. Science of the Total Environment, 718, art. no. 134468, . DOI: 10.1016/j.scitotenv.2019.134468
4. Aryal, N., Wood, J., Rijal, I., Deng, D., Jha, M.K., Ofori-Boadu, A. (2020) Fate of environmental pollutants: A review. Water Environment Research, 92 (10), pp. 1587-1594. DOI: 10.1002/wer.1404
5. Børgensen, Fomsgaard, Plauborg, Schelde, Spliid. (2015) FATE OF PESTICIDES IN AGRICULTURAL SOILS. DCA - DANISH CENTRE FOR FOOD AND AGRICULTURE REPORT NO. 062 · JUNE 2015

6. DIRECTIVE 2009/128/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides
7. EFSA Guidance Document for predicting environmental concentrations of active substances of plant protection products and transformation products of these active substances in soil. EFSA Journal 2017;15(10):4982
8. https://ec.europa.eu/environment/strategy/chemicals-strategy_en
9. https://ec.europa.eu/environment/water/water-framework/index_en.html
10. https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_en

Number of classes

Lectures (teoretical , practical lessons, seminars = contact hours): 20 hours	**Student research work:** -	**Other activities (preparation for exam, literature research, preparation of seminars etc): 55 hours**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title		Toxicology and Ecotoxicology of Pesticides	
Course code		TEP	
Course leader		Dragica Brkić (UB)	
Responsible PI (University/Faculty/Department/Country		University of Belgrade, Faculty of Agriculture, Serbia	
Additional course leaders (University/Faculty/Department/Country)		Matteo Spagnuolo (UNIBA); Sanja Lazić (UNS); Magdalena Cara (AUT)	
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	None		
Learning outcomes	Describe specific target organs and molecular mechanisms of toxicity of pesticides. Apply different toxicological and ecotoxicological frameworks within the professional disciplines and have awareness about different risk assessment criteria. Critically evaluate toxicological information from different sources (EFSA, EC, IPCS, ATSRD etc. databases). Develop a critical attitude towards new OECD test guidelines in toxicology and ecotoxicology. Independently carry out and recommend risk assessment of pesticides for different organisms. Estimate the risk for adverse effects of a chemical on different biological organisation levels.		
Students compentences	Ability to work in a multidisciplinary team dealing with problems of risk assessment of pesticides for different organisms. Ability to apply the standards and regulations concerning placing of PPP on the market as well as pesticide residues and food safety. Independently carry out classification and labelling of pesticides according to GHS system for classification and labelling.		
Course content			

Thematic units	***Theoretical classes:*** Pesticides and specific target organs; molecular mechanisms of toxicity of pesticides: covalent binding to endogenous substrates, inhibition of enzymes and other proteins, oxidative stress, mechanisms of apoptosis and necrosis, effect of toxins on ion channels and specific receptors, etc. Effects of pesticides on human health and the environment. Response of an individual, population, community and ecosystem to one or more pesticides (molecular, physiological and behavioral level). Toxicity of mixtures. New approaches in toxicological and ecotoxicological testing. Bioconcentration, bioaccumulation and biomagnification of pesticides and entering the food chain. The need for standards and regulations in toxicology and ecotoxicology. Problems of pesticide residues in food and feed. Residues of pesticides of toxicological significance. Food safety. Regulations concerning the food safety and protection from pollution. Regulations concerning the placing of PPP on the market in EU. Human and ecological risk assessment. Direct and indirect effects of pesticides important for risk assessment. Principles in hazard and risk assessment based on dose-response and exposure assessment. ***Practical classes:*** Methods to study toxic and ecotoxic effects of pesticides (in vivo, in vitro, in silico). Determination of Hazard Quotient (HQ) for different organisms, Toxicity Exposure Ratio (TER), Regulatory Acceptable Concentration (RAC), etc. and interpretation of results. EFSA OpEx model for the assessment of exposure of operators, workers, residents and bystanders in risk assessment for PPP. EFSA residue intake model (EFSA PRIMo). Laboratory work and individual research. Classification and labelling of pesticides in relation to toxicological and ecotoxicological properties (health and environmental hazard) according to GHS system for classification and labeling.
Literature and other learning material:	

1. Kreiger, R. (Ed). Hayes' Handbook of Pesticide Toxicology. Academic Press, London, UK, 2010.
2. Casarett & Doull's Essentials of Toxicology (8th Edition), Klaassen, D.C, Watkins, B.J. (Eds). Mc Graw Hill Medical, New York, USA, 2015.
3. Dewhurst, C.I., Marrs, C.T. Toxicology of Pesticides. In: General and Applied Toxicology (Third edition), Ballantyne, B, Marrs, C.T., Syversen, T. (Eds). John Wiley and Sons, Ltd, West Sussex, England, 2011.
4. Newman, C.M. Fundamental of Ecotoxicology, The Science of Pollution. CRC Press, Boca Raton, FL, USA, 2015.
5. OECD test guidelines for the chemicals.
6. EFSA Guidance on the assessment of exposure of operators, workers, residents and bystanders in risk assessment for PPP.
7. Use of EFSA pesticide residue intake model (EFSA PRIMo revision 3).

Number of classes (= workload of students)

Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
20 hours	**-**	**55 hours**

Teaching procedures: PPT presentations, other didactic tools, seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures	15	**Written**	20
Practical classes	15	**Oral**	20
Colloquium			
Seminar papers	30		

A way to form a final grade:

Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Focus area 3: Plant feeders

Course title		Advanced techniques in plant feeders	
Course code		ATPF	
Course leader		Biljana Vidović (UB)	
Responsible PI (University/Faculty/Department/Country		UB University of Belgrade/Faculty of Agriculture/Department of Entomology and Agricultural Zoology/ Serbia	
Other teachers and related PIs (University/Faculty/Department/Country)		**Mirjana Brmež** (FAZOS: University of Osijek/ Faculty of Agriculture/Department of Plant Protection/ Croatia) **Ivana Pajač Živković** (FAZ: University of Zagreb/ Faculty of Agriculture/Department of Agricultural Zoology /Croatia) **Nedžad Karić** (UNSA:University of Sarajevo, Faculty of Agriculture and Food Sciences/ Department of Plant Protection/Bosnia and Herzegovina) **Ioannis Giannakou** AUA/Agricultural University of Athens/Faculty of Crop Science/ Department of Zoology and Entomology/ Greece **Daniele Cornara** (UNIBA: University of Bari/Department of Soil, Plant and Food Sciences/ Italy	
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Knowledge and understanding of various methods that are used in scientific research for field and laboratory work with plant feeders such as: collecting, making a collection and slides, examination of morphology and anatomy, bioecology, rearing under controlled conditions, sampling for qualitative and quantitative analysis and using basic specialized		

	methods, as well as general methods which could be useful for candidate's dissertation.
Learning outcomes	- Knowledge of theoretical basis of certain general and specialized methods for plant feeders. - Assess which kinds of methods are necessary and applicable for different field and laboratory research. - Ability to use certain methods while working in the field and laboratory conditions. - Ability to setting and use of equipment - Design the protocol, performing and combine different methods - Ability to independently apply and correctly interpret the results of experimental work
Course content:	
1. Topic: techniques of sampling, isolation and identification insects Subtopics: general properties of the various groups of insects; methods of collecting, fixation, making insects slides and durable preparations; methods of making histological preparations; methods for monitoring insects in the field and quantitative analysis of their populations; methods of growing insect and molecular methods in entomology. 2. Topic: techniques of sampling, isolation and identification mites Subtopics: collecting and extraction mites species from different substrates; methods of fixation, clearing, mounting, examination of morphology and preparing mites for further morphological microscopic and molecular analyses; methods of determination of population density and the parameters of population growth. 3. Topic: techniques of sampling, isolation and identification nematodes Subtopics: principles and techniques of collecting nematodes in spontaneous and anthropogenic ecosystems; methods of extracting nematodes from soil, plants, insects and slugs; methods of preparing nematodes for further morphological microscopic and molecular expertise; use of identification keys for nematodes; rearing nematodes for specific research aims; experimental methods in nematology	
Literature and other learning material:	

1. Upton, M. S. & Mantle, E. L. 2010.Methods for Collecting, Preserving and Studying Insects and Other Terrestrial Arthropods. Australian Entomological Society. pp. 83.
2. Southwood, T.R.E., Henderson P.A. 2000. Ecological Methods. Third Edition. Published by Blackwell Science Ltd. pp. 575.
3. Marjorie Hoy 2018. Insect Molecular Genetics 4th Edition. Academic Press. 705 pp.
4. Krantz, G.W. Walter, D.E. (eds.) 2009. A manual of Acarology. Texas Tech University Press, Lubbock, Texas, pp. 807.
5. Hoy, M. A. 2011. Agricultural Acarology Introduction to Integrated Mite Management. Taylor and Francise Group, LLC, New York pp.410.
6. Perry R.N., Hunt D., Subbotin S. 2020. Techniques for work with plant and soil nematodes. Publisher CABI. pp.606.

Relevant recent scientific articles published in scientific journals

Number of classes: 75

Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:** -	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
20 hours		**55 hours**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory, seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade: formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title		Frontiers in invertebrate pest and resistance management	
Course code		FIPRM	
Course leader		Anita Liška (FAZOS)	
Responsible PI University/Faculty/Department/Country		FAZOS	
Other teachers and related PIs (University University/Faculty/Department/Country)		Ankica Sarajlić (FAZOS), Vlatka Rozman (FAZOS), Darija Lemić (FAZ), Anđa Radonjić (UB), Giovanni Tamburini (UNIBA)	
Credits (ECTS)	**4**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Acquiring knowledge and understanding of behavioural responses of invertebrate pest according to different agro-ecological factors. Introduce the students to a novel non-pesticides control measures in the protection of filed, crop and stored products with the emphasis of the latest key findings. Acquiring knowledge and skills in the resistant pest populations monitoring and applying anti-resistant strategies. Student will be able to guide and monitor filed trial applying the latest knowledge of non-pesticides measures and techniques.		
Learning outcomes	After completing the PhD study program student will be able to: 1. Estimate the abundance dynamic of invertebrate pest according to the agro-ecological factors 2. Compare and asses novel green insecticides as an alternative to synthetic pesticides 3. Design protocols for the application of non-pesticides measures 4. Interpret the use of the Internet of Things (IoT) implementation in prediction and monitoring the occurrence of invertebrate pests 5. Estimate the potential for pesticide resistance development and analyse resistance trends		

	6. Evaluate new technologies and diagnostic methods for the detection of resistant populations among invertebrate pests 7. Critically analyze of practical resistance – management strategy

Course content:

Theoretical lessons:

Abiotic factors and pest abundance; Prediction models of pest abundance in pre- and post-harvest crop; New approach in invertebrate pest control; Tolerant and resistant cultivars; Green pesticides and nanotechnology; Internet of Things (IoT); Monitoring and population density estimation; Pest resistance management; Detection and tools; Anti-resistant strategy

Practical lessons: laboratory exercises

Training and conducting different protocols for testing resistant population among invertebrate pests

Literature and other learning material :

1. Kadoić Balaško, M., Bažok, R., Mikac, K. M., Lemic, D., & Pajač Živković, I. (2020). Pest Management Challenges and Control Practices in Codling Moth: A Review. Insects, 11(1), 38.
2. Mrganić, M., Bažok, R., Mikac, K. M., Benítez, H. A., & Lemic, D. (2018). Two decades of invasive Western corn rootworm population monitoring in Croatia. Insects, 9(4), 160.
3. Hagstrum, D.W., Philips, T.w., Cuperus, G. (2012): Stored Product Protection. Kansas State University https://www.bookstore.ksre.ksu.edu/pubs/S156.pdf
4. Paponja, I., Rozman, V., Liška, A. (2020). Natural Formulation Based on Diatomaceous Earth and Botanicals against Stored Product Insects. Insects, 11(9), 613, 10.
5. Gao, D., Sun, Q., Hu, B., Zhang, S. (2020): A Framework for agricultural Pest and Disease Monitoring Based on Internet-of-Things and Unmanned Aerial Vehicles. Sensors, 20:1487.
6. Rasche, L., Taylor, R.A.J. (2019): EPIC-GILSYM: Modelling crop-pest insect interactions and management with a novel coupled crop-insect model. Journal of Applied Ecology, 56:2045-2056.
7. Mikac, K.M., Lemic, D., Benitez, H.A., Bažok, R. (2019): Changes in corn rootworm wing morphology are related to resistance development. Journal of pest science. 92:443–451.

Number of classes

Lectures (theoretical , practical lessons, seminars = contact hours):	Student research work:	Other activities (preparation for exam, literature research, preparation of seminars etc.):
	-	

30 hours		70 hours
Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory, seminars /round tables/workshops		
Evaluation (max. 100 points)		

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title	Advanced Invertebrate Pathology		
Course code	AIP		
Course leader	Eustachio Tarasco (UNIBA)		
Responsible PI University/Faculty/Department/Country	University of Bari /Department of Soil, Plant and Food Sciences /Italy(UNIBA)		
Other teachers and related PIs (University University/Faculty/Department/Country)	Ivana Majić (FAZOS), Maja Čačija (FAZ), Ioannis Giannakou (AUA), Nikola Grujić (UB)		
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	Basic knowledge of invertebrate pathology: 1) Insect Pathology and Microbial Control Background, 2) Use of pathogens in biological control, 3) Comparative data on the biology of the major groups of insect pathogens. Positive approach with search engines and digital devices. Competence in use of major SW packages, Microsoft Office, Adobe, Statistics and similar.		

Aim of the course and student `s competences	Provide in-depth knowledge of different aspects of Invertebrate pathology: isolation and maintenance in the laboratory of pathogens and applied microbiological control methods and techniques. The course will create an expert in Microbial Control Pest Management. Acquire specific and in-depth skills in: Laboratory techniques in Invertebrate pathology: isolation and maintenance of the pathogens, evaluation bioassays. Field techniques in invertebrate pathology: application and evaluation of pathogens for control of insects and invertebrate pests
Learning outcomes	*Knowledge and understanding* Knowledge of the basic elements of Invertebrate pathology Knowledge of pathogens (virus, bacteria, protozoa, fungi and nematodes) in biological control *Applying knowledge and understanding* Ability to assess microbial control pest management in agro forestry ecosystems Ability to analyse and manage microbial control methods and technologies in IPM strategies *Making informed judgements and choices* Ability to analyse and manage the use of pathogen-based products within environmental contexts in the light of the reports between human activities and the natural environment. Ability to evaluate the most suitable solution to eco-friendly management *Communicating knowledge and understanding* Ability to present the results of projects/research and develop jobs by themselves or in group activities, through the preparation of technical reports and oral exposure, using an appropriate technical language *Capacities to continue learning* Ability to ensure the continuous updating of knowledge in the specific field of Invertebrate Pathology, even with tools that make use of new communications technologies and information technology

	Ability to deal with the typical problems of agro-forestry ecosystems, including through innovative technical solutions

Course content:

Theoretical and Practical lessons

1. Pathogens used in biological control: Virus, Bacteria, Protozoa, Fungi and Nematodes
2. Microbial insecticides based on Virus (Baculovirus), Bacteria (Bacillus thuringiensis), Protozoa (Microsporidia), Fungi (and their mycotoxins) and Nematodes (Steinernematidae, Heterorhabditidae and their symbiotic bacteria) - mode of action, toxicology to human and beneficials, ecotoxicology: fate and behavior in the environment
3. Main characteristics of Microbial insecticides
4. Application of Microbial insecticides in the field and in the storage.

Literature and other learning material :

- LA Lacey 2017 – Microbial control of insect and mite pests
- LA Lacey 2012 - Manual of techniques in invertebrate pathology.
- LA Lacey, HK Kaya - 2007 - Field manual of techniques in invertebrate pathology: application and evaluation of pathogens for control of insects and other invertebrate pests. Springer
- R Gaugler 2002 - Entomopathogenic nematology. Wallingford, Oxon, CABI Publishing
- R Gaugler & HK Kaya, H.K. Entomopathogenic nematodes in biological control. Boca Raton, Florida, CRC Press

Number of classes

Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
20 hours	**-**	**55 hours**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20

Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		
A way to form a final grade: Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.			

Course title		Invasive Alien Pests	
Course code		IAP	
Course leader		Francesco Porcelli	
Responsible PI (University/Faculty/Department/Country)		**University of Bari Aldo Moro (UNIBA)**	
Other teachers and related PIs (University/Faculty/Department/Country)		Ivana Pajač Živković (FAZ); Ankica Sarajlić (FAZOS); Aleksandra Konjevic (UNS); Dušanka Jerinić-Prodanović (UB); Snježana Hrnčić (UoM) Mladen Zovko (SVEMO)	
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	The course aims to build into the student a vision of the topic by the acquisition of critical new knowledge, offering effective answers to significant control needs. The course will create an expert ready to survey real cases of Alien Invasive Pest management. Knowledge at the frontier in analysis and synthesis, redefining the Invasive management background interfacing with nearby topics in problem solving. The student aims to demonstrate authority, innovation,		

	autonomy, integrity and commitment at the forefront of work or study contexts including research in the topics below: a) α-taxonomic Invasive critical identification and evaluation of advanced identification methods information; b) slide mounting and Invasive taxonomic features understanding and communicating by digital devices in a collaborative and innovative environment of personal growth by transferable skills; c) Proactive and creative Invasive -management-oriented use of project-management software, including key points and critical path analysis; d) Estimation of Invasive action & economic thresholds e) Building Invasive management scenarios to choose within effective IPM control strategy f) Evaluating the plant Invasive risk on introduction in a Country or into a biome, in a globally changing world citizenship.
Learning outcomes	1) Ability to spot an insect as non-indigenous and to suspect its identity by α-taxonomic tools; 2) Understanding advanced methods of Invasive identification; 3) Preparing and shipping voucher specimens, including the ability to mount the Invasive on slides and share taxonomic features with available specialists by digital devices; 4) Built tentative lifetable for the Invasive and describe its invasion options by generic or project-management software, including key points and critical path for the pest; 5) Detail, discuss and scrutinize the economic & action thresholds on the basis of Invasive bionomics. To choose the appropriate control means, and quantifying control pressure, timing, and expected results; 6) Understand resistance management and evaluate hosts and plant resistance mechanisms to the Invasive; 7) Built the appropriate Invasive control strategy, evaluate the contribution of integration to the built IPM strategy; 8) Understand the approach to plant Invasive risk assessment in upcoming agricultural changes and climate fluctuations;

Course content:
Theoretical lessons; 1. The Alien Invasive species 2. Basic Pest Management Tools 3. Invasive and non-Invasive species management 4. Previewing and forecasting the invasion process *Practical lessons:* Practical on the topics
Literature and other learning material :
• Beutel R.G., Friedrich F., Si-Qin Ge, Xing-Ke Yang (2014). Insect Morphology and Phylogeny A textbook for students of entomology. De Gruyter, 516 pp. ISBN 978-3-11-026263-6 e-ISBN 978-3-11- 026404-3 • Gibb T. (2015). Contemporary insect diagnostics the art and science of practical entomology, Elsevier, 336 pp. ISBN: 978-0-12-404623-8 • Gullan P.J. & Cranston P.S. (2014). The insects: an outline of entomology, Fifth edition, 613 pp. ISBN 978-1-118-84615-5 • Roques A., Kenis M., Lees D., Lopez-Vaamonde C., Rabitsch W., Rasplus J-Y., Roy D.B. (Ed.s) (2010). Alien terrestrial arthropods of europe. BioRisk 4 Special Issue, 1021 pp. • Course handouts
Number of classes:

Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
20	**-**	**55**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory, seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			

Seminar papers (=Seminar(s))	30		
A way to form a final grade: The final grade is formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.			

Course title	Vectors of plant pathogens		
Course code	VPP		
Course leader	Olivera Petrović-Obradović		
Responsible PI (University/Faculty/Department/Country	**UB, Serbia**		
Other teachers and related PIs (University/Faculty/Department/Country)	Tanja Gotlin Čuljak (FAZ) Croatia Sanja Radonjić (UoM) Montenegro Ivana Majić (FAZOS) Croatia Daniele Cornara (UNIBA) Italia		
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Understanding of different animal groups, i.e. vectors of plant pathogens (insects – Hemiptera: Sternorrhyncha and Auchenorrhyncha, Thysanoptera, mites, nematodes and snails), morphology and anatomy of vectors, modes of viral, phytoplasmatic, bacterial and fungal transmission. Knowledge of main vector control measures by applying methods of active lectures and usage of updated literature. Students have to develop capacity to transfer knowledge into practice, to develop team work and critical mind.		
Learning outcomes	After completing the courses, student will be able to: 1. Identify vectors of plant pathogens following the protocols of advanced methods. 2. Judge the importance of vectors ecological and biological characteristics for their interactions and survival.		

	3. Discuss the modes of vectors spread and plant pathogen transmission. 4. Design monitoring plan and models for vectors predictions. 5. Asses the protocols and available control methods. 6. Argue the bottle-necks in research and gaps in knowledge related to vectors of plant pathogen**.**

Course content:

1. Topic: main vector properties.
   Subtopics: ecology of vector populations; modes of virus transmission (intake, incubation period, multiplication); phytoplasma transmission, bacteria and fungi transmission.
2. Topic: vector activity.
   Subtopics: plant reactions; main vector types; interactions of vectors of plant pathogens
3. Topic: main vector types
   Subtopics: Hemiptera (aphids, psylids, aleurodids, cicadae), Thysanoptera, mites, nematodes and snails.
4. Topic: identification of vectors, methods of modeling population dynamics, population stability and control;
   Subtopics: methods of morhphological and molecular identification, predicting, monitoring, evaluating and modeling the establishment of stable populations; control measures for minimizing their role in plant disease epidemiology.
5. Topic: Advanced molecular methods to identify pests and pathogens (different PCR methods).

Theoretical lessons: PPT presentations.

Practical lessons: Demonstrations in field, practical work in laboratory.

Literature and other learning material :

1. Radivojević M. (2020) “Plant Nematology” (in Serbian), University of Belgrade, Faculty of Agriculture.

2. Jerinić-Prodanović, D. (2020): Psylids (Hemiptera: Psylloidea) pest of cultivated plants in Serbia. (in Serbian) University of Belgrade, Faculty of Agriculture, 168 p.
3. Weintraub G. Phyllis, and Beanland LeAnn (2006): Insect vectors of phytoplasmas. Annu. Rev. Entomol. 51: 91–111.
4. Dietzgen G. Ralf, Mann S. Krin and Johnson N.Karyn (2016): Plant Virus–Insect Vector Interactions: Current and Potential Future Research Directions. Viruses, 8, 303; doi:10.3390/v8110303 www.mdpi
5. David R. Jones (2003): Plant viruses transmitted by whiteflies. European Journal of Plant Pathology, 195–219.
6. David R. Jones (2005): Plant viruses transmitted by thrips. European Journal of Plant Pathology. 113: 119–157
7. Jarausch Barbara, Weintraub Phyllis, Sauvion Nicolas, Maixner Michael, Foissac Xavier (2014): Diseases and insect vectors. Chapter 3. In: Phytoplasmas and phytoplasma disease management: how to reduce their economic impact. Ed. By Assunta Bertaccini. COST Action FA0807 Integrated Management of Phytoplasma Epidemics in Different Crop Systems. IPWG - International Phytoplasmologist Working Group
8. Perilla-Henao M.Laura and Clare L. Casteel (2016): Vector-Borne Bacterial Plant
9. Pathogens: Interactions with Hemipteran Insects and Plants. Frontiers in Plant Science, Volume 7 | Article 1163, doi: 10.3389/fpls.2016.01163.

Number of classes		
Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
20 hours	**-**	**55 hours**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory, seminars /round tables/workshops .

Evaluation (max. 100 points)			
Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			

Seminar papers (=Seminar(s))	30		
A way to form a final grade: Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.			

Course title	Integrated management of urban pests		
Course code	IMUP		
Course leader	Ignjatović Ćupina Aleksandra (UNS),		
Responsible PI (University/Faculty/Department/Country	University of Novi Sad, Faculty of Agriculture, Department for Environmental and Plant Protection, Serbia		
Other teachers and related PIs (University/Faculty/Department/Country)	Nedžad Karić (UNSA), Aleksandar Mešić (FAZ), Draga Graora (UB), Igor Pajović (UoM), Eustachio Tarasco (UNIBA) Aleksandra Petrović (UNS)		
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student`s competences	Aims: Acquiring knowledge on insect fauna in urban and semiurban habitats, role and importance of insect species in relation to the environment, human health and welfare; knowledge, skills and competences for designing and implementation of integral strategies for surveillance of native and invasive pest species in urban environment, prevention of pest species occurrence, population growth and spreading, selection of environmental friendly and effective control strategies and evaluation of treatment efficacy. Student`s competences: **a**cquired knowledge and skills in planning and application of integrated management of urban pests, with respect to human and animal health and welfare and environmental protection;		

	competences in designing and implementation of surveillance strategies, decision making, selection and application of adequate methods of monitoring and control of urban pests.
Learning outcomes	• Identification of urban pest species and evaluation of consequences of their activity to environmental and human health and welfare • Design effective strategies of surveillance and strategies of environmental friendly integrated management of urban pests, with respect to safety of human population and environmental health, and cost effectiveness. • Selection, development, implementation and validation of appropriate methods of monitoring of urban native and alien pest species, evaluation of pest population density, seasonal and spatial distribution, interpretation of population dynamics and determination of appropriate time for control treatment implementation, based on knowledge of species biology, ecology and monitoring results • Evaluate the risks of introduction and spreading of invasive urban pest species, design and apply protocols for prevention of introduction, early detection and surveillance • Analyze and identify the reasons for occurrence of urban pest species, as well as scenarios of introduction of invasive urban pest species. • Selection and adequate implementation of effective and environmental friendly control methods and techniques, evaluation of treatment efficacy • Commitment to One Health approach of integral multidisciplinary surveillance of vectors and vector borne diseases that affect human and animal health • Design and conduct field and laboratory research in the area of integrated management of urban pests.
Course content:	
Theoretical lessons:	

Urban environment and insects; Pests in urban environment: insects which affect the ambiental hygiene, molestants and vectors of transmissive diseases; pests of ornamental plants, pests of wood, pests in urban agriculture; Beneficial insects and their conservation in urban environment; Integrated approach to management of native and alien pest species in urban environment, protocols for their surveillance; monitoring techniques, prevention and signalization of outbreaks, environmental friendly control strategies: physical, biological, chemical and genetic control, sterile insect Technique (SIT), data collection and analysis. Invasive species of urban pests, prevention of their introduction, early detection, eradication and suppression strategies. Citizens` science: role and importance of the society in prevention and early detection of invasive pest species, involvement in surveillance programs. One Health Concept as multidisciplinary approach to surveillance of vectors and vector borne diseases that affect human and animal health. Case studies and practical experiences.

Practical classes:

Practical training in methods of pest insect species detection in urban environment, selection and application of different monitoring techniques, control strategies and evaluation of treatment efficacy; field and laboratory exercises on targeted species.

Literature and other learning material:

- Robinson W.H. (2005): Handbook of Urban Insects and Arachnids. Camabridge University Press, UK. 472 pp.
- Lane R.P., Crosskey R.W. (1993): Medical Insects and Arachnids. Springer Science+Business Media Dordrecht. 723 pp.
- Takken W., Knols B.G.J. (2010): Emerging pests and vector-borne diseases in Europe. Ecology and control of vector-borne diseases Volume 1. Wageningen Academic Publishers, Netherlands. 499 pp.
- Becker N., Petrić D., Zgomba M., Boase C., Dahl C., Madon M., Kaiser A. (2010): Mosquitoes and Their Control. Second Edition. Springer-Verlag Berlin Heidelberg. 577 pp.
- Matthews G. (2011): Integrated Vector Management Controlling Vectors of Malaria and Other Insect Vector Borne Diseases. Wiley-Blackwell, UK. 234 pp.
- European Centre for Disease Prevention and Control; European Food Safety Authority (2018): Field sampling methods for mosquitoes, sandflies, biting midges and ticks – VectorNet project 2014–2018. Stockholm and Parma: ECDC and EFSA.37 pp

- European Centre for Disease Prevention and Control (2012): Guidelines for the surveillance of invasive mosquitoes in Europe. Stockholm: ECDC. 95 pp
- Dyck V.A., Hendrichs J., Robinson A.S. (2021): Sterile Insect Technique. Principles and Practice in Area Wide Integrated Pest Management. Second edition, CRC Press Taylor and Francis Group. 1200 pp.

Number of classes:

Lectures (teoretical , practical lessons, seminars = contact hours):	Student research work:	Other activities (preparation for exam, literature research, preparation of seminars etc):
20	**-**	**55**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	Points	Final exam	Points
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

The final grade is formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Focus area 4: Plant pathology

Course title	Molecular Plant Microbe Interactions
Course code	MPMI
Course leaders	Sotiris Tjamos (AUA), Rita Milvia De Miccolis Angelini (UNIBA)

Responsible PI University/Faculty/Department/Country		• Agricultural University of Athens / Faculty of Crop Science/Department of Phytopathology/Greece (AUA); • University of Bari /Department of Soil, Plant and Food Sciences /Italy(UNIBA)	
Other teachers and related PIs (University/Faculty/Department/Country)		Epaminondas Paplomatas (AUA), Dimitris Tsitsigiannis (AUA), Natasa Duduk (UB), Renata Iličić (UNS), Arnela Okić (UNSA), Ana Crnogorac (SVEMO), Karolina Vrandečić (FAZOS), Jelena Latinović (UoM)	
Credits (ECTS)	**4**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	The main aim of the course is the students to acquire knowledge on plant – microbe interactions. The specific aims are the students to acquire knowledge on how: 1. fungi/oomycetes, bacteria, viruses invade plants 2. plants defend against biotrophs and necrotrophs 3. to use plant immunity against plant pathogens Acquired knowledge, skills and competences for working in: 1. Plant Breeding and Biotechnology companies 2. Academia		
Learning outcomes	The learning outcomes for the students are to be able to: 1. Formulate scientific hypothesis on plant - microbe interaction 2. Design Experiments based on correct methodology 3. Collect Experimental data from in planta experiments 4. Analyze Experimental data 5. Compare and Conclude to scientific results		
Course content:			
Theoretical lessons: Fungal/Oomycete pathogenesis; Bacterial pathogenesis; Viral pathogenesis; Defense responses in plants; Effector-Triggered susceptibility; PAMP-Triggered immunity; Effector-Triggered immunity ; R-genes, structure and function. *Practical lessons:*			

Experimental methods in Molecular Plant Microbe Interaction research			
Literature and other learning material:			
1. Cook et al. 2015. Understanding Plant Immunity as a Surveillance System to Detect Invasion Annual Review of Phytopathology 53:1, 541-563 2. Fu et al. 2013. Systemic Acquired Resistance: Turning Local Infection into Global Defense. Annual Review of Plant Biology 64:1, 839-863 3. Hann et al. 2010. Bacterial virulence effectors and their activities. Current Opinion in Plant Biology 13:388–393 4. Mandadi et al 2013. Plant Immune Responses Against Viruses: How Does a Virus Cause Disease? The Plant Cell 25 (5) 1489-1505 5. Melotto M. and Kunkel BN 2013. Virulence Strategies of Plant Pathogenic Bacteria. In: Rosenberg et al. (eds.), The Prokaryotes – Prokaryotic Physiology and Biochemistry, DOI 10.1007/978-3-642-30141-4_62, Springer-Verlag Berlin Heidelberg 6. Presti et al. 2015. Fungal Effectors and Plant Susceptibility. Annual Review of Plant Biology 66:1, 513-545 7. Pieterse et al. 2014. Induced Systemic Resistance by Beneficial Microbes. Annual Review of Phytopathology 52:1, 347-375 8. Singh, A. and Singh, I.K. eds., 2018. Molecular Aspects of Plant-Pathogen Interaction. Springer. Stassen et al. 2011. How do oomycete effectors interfere with plant life? Current Opinion in Plant Biology 14: 407-414			
Number of classes			
Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**	
30	**-**	**70**	
Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars /round tables/workshops			
Evaluation (max. 100 points)			
Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20

Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		
A way to form a final grade: Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.			

Focus area 5: Weed science

Course title	Weed management in precision agriculture		
Course code	WMPA		
Course leader	Dragana Božić		
Responsible PI University/Faculty/Department/Country	UB, Serbia		
Other teachers and related PIs (University University/Faculty/Department/Country)	Skender Varaku (AUT), Albania Maja Šćepanović (FAZ), Croatia Marija Ravlić (FAZOS), Croatia Teofil Gavrić (UNSA), Bosnia and Herzegovina Aleksandar Sedlar (UNS), Serbia		
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	This course will provide an introduction to concepts, technologies and implementations strategies of weed management in precision agriculture. It is designed to enable students to understand and use techniques and technologies developed for weed management in precision agriculture and their application in sustainable crop production, through automatic weed detection and mapping, management decisions, site – specific weed control (GPS-controlled herbicide application, precision mechanical weed control, use agricultural robots and nanotechnology).		

	Students will be competent to use adequate literature data for weed management in precision agriculture, to design experiments for investigation of use precision agriculture techniques and technologies in weed management, and collaborate with other students and professionals in the field of precision weed management. Also, students will be ready to critically analyze strategies of weed management in precision agriculture.
Learning outcomes	After completing the course, student will be able to: 1. Asses possibility of implementation principles of precision agriculture in sustainable weed management 2. Describe the principles of precision agriculture and their application in weed management 3. Relate the specifics of particular weed species to precision agriculture techniques 4. Explain data collection, analysis and application in precision weed management 5. Evaluate he major barriers and challenges to weed management in precision agriculture 6. Conduct field research in weed control applying precision agriculture techniques
Course content:	
Teaching 1. Principles of precision agriculture applicable in weed management: a. Geographic information systems (GIS) b. Global positioning systems (GPS) c. Site-specific weed control d. Remote sensing systems e. Variable rate application 2. Data collection, analysis and application in precision weed management 3. Automatic detection and classification of weeds (weed seedlings) using remote sensing (satellite or manned/unmanned aircrafts, optical or reflectance-based sensors, hyper spectral remote sensing) and weed mapping (density and distribution)	

4. Weed management decision support system based on precision agriculture approach
5. Precision (site-specific) weed control:
   a. GPS-controlled herbicide application
   b. Precision mechanical weed control
   c. Use agricultural robots and drones
   d. Use nanotechnology and nanoherbicides
6. Ecological and economic benefits of precision weed management

Practical classes

1. Student research paper on weed management in precision agriculture
2. 2. Field exercises on application precision agriculture techniques and technologies in weed management

Theoretical lessons: PPT presentations.

Practical lessons: Demonstrations in field, practical work in laboratory.

Literature and other learning material:

1. Srinivasan, A. (Ed.) (2008): Hanbook of precision agriculture: Principles and Applications. Food products press, Binghamton, NY, USA.
2. Stafford J.V. (ED.) (2013):Precision agriculture '13. Wageningen Academic Publishers, Wageningen.
3. Billingsley, J. (Ed.) (2019): Robotics and automation for improving agriculture, 44 of Burleigh Dodds Series in Agricultural Science Series. Burleigh Dodds Science Publishing, Cambridge, UK.
4. Young, S. L., Pierce, F.J. (Eds.) (2014): Automation: The Future of Weed Control in Cropping Systems. Springer Dordrecht Heidelberg New York London, e-book.
5. Oerke, E.-Ch., Gerhards, R., Menz, G., Sikora, R. A. (Eds.) (2010): Precision Crop Protection - the Challenge and Use of Heterogeneity. Springer, Dordrecht Heidelberg London New York.
6. Rocha, F. C., Oliveira Neto, A.M. Bottega, E.L., Guerra, N., Rocha, R.P., Vilar, C.C. (2015): Weed Mapping Using Techniques of Precision Agriculture. Planta Daninha, Viçosa-MG, 33(1), 157-164.
7. Chirstensen, S., Sogaard, H.T., Kudsk, P., Norremark, M., Lund, I., Nadimi, E. S., Jorgensen, R. (2009): Site-specific weed control technologies. Weed Research 49, 233–241.
8. Torres-Sánchez, J., López-Granados, F., De Castro, A.I., Peña-Barragán, J.M. (2013): Configuration and Specifications of an Unmanned Aerial Vehicle (UAV) for Early Site Specific Weed Management. PLoS ONE 8(3): e58210.

9. Jiménez-Brenes, F.M., López-Granados, F., Torres-Sánchez, J., Peña, J.M., Ramírez, P., Castillejo-González, I.L., et al. (2019) Automatic UAV-based detection of *Cynodon dactylon* for site-specific vineyard management. PLoS ONE 14(6): e0218132.
10. Huang, Y., Reddy, K., Fletcher, R., Pennington, D. (2018): UAV Low-Altitude Remote Sensing for Precision Weed Management. *Weed Technology, 32*(1), 2-6.
11. Pallottino, F.; Menesatti, P.; Figorilli, S.; Antonucci, F.; Tomasone, R.; Colantoni, A.; Costa, C. Machine Vision Retrofit System for Mechanical Weed Control in Precision Agriculture Applications. *Sustainability* 2018, *10*, 2209.

Number of classes: 75

Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
20 hours	**-**	**55 hours**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title		Modelling in Weed Science	
Course code		MWS	
Course leader		Maja Šćepanović	
Responsible University/Faculty/Department/Country		University of Zagreb, Faculty of Agriculture Department of Weed Science	
Additional course leaders (University University/Faculty/Department/Country)		Jasmin Grahić (UNSA), Bosnia and Herzegovina, University of Sarajevo Faculty of Agriculture and Food Sciences Sava Vrbničanin (UB), University of Belgrade , Faculty of Agriculture, Serbia Maja Meseldžija (UNS), University of Novi Sad , Faculty of Agriculture, Serbia	
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course	This course provides an introduction to concepts, technologies, and implementations of modelling in weed science. It is designed to enable students to understand the principles and techniques of weed modelling (bio-economic models; weed emergence models) as part of precision weed management. The use of herbicides at optimised timing is one of the most important tools to limit herbicide input into the environment according to the Integrated Weed Management. Therfore, pparticular emphasis will be placed on hydrothermal weed emergence models that predict peak weed emergence based on soil temperature and soil moisture to help farmer develop an efficient management program for weed control in cultivated crops. Due to the specific weed biology, particular importance is given to the adaptation of the predictive weed growth model for a given agro-ecological area		

Learning outcomes	At the end of the course, the student must demonstrate knowledge and understanding of: (1) principles of weed modelling and their application in weed management (2) understanding and application of keys to building bio-economic and weed emergence models (3) acquisition of laboratory and field skills necessary to build or apply weed models (4) development of critical thinking about course content and the ability to present knowledge gained in this course.
Students competences	Students will be able to think critically about the use of models in weed science, use adequate literature data on weed modelling, and collaborate with other students and professionals in the field of weed modelling. In addition, students will have enough information to plan laboratory or field experiments in weed modelling.
Course content	
Thematic units	*Teaching* 1. Sustainable integrated weed management solutions and the use of herbicides at optimised timing 2. Overview of models used in Weed Science : Population dynamics model Bio-economic models (Decision support model) Predictive weed emergence models 3. The importance of modelling germination, emergence and early growth of weed species for site-specific weed management 4. Weed germination and emergence data are a basis for the development of hydrothermal predictive weed emergence model *Practical classes* 1. Student's research work on weed modeling 2. Laboratory and field exercises

Literature and other learning material

- MS-MWS- Bürger, J., Colbach, N. -2018. Germination base temperature and relative growth rate of 13 weed species – comparing populations from two geographical origins, 28th German Conference on Weed Biology and Weed Control, Julius-Kuhn-Archiv 458: 419-426.
- MS-MWS- Dahlquist, R., Prather, T., Stapleton, J.- 2007. Time and temperature requirements for weed seed thermal death. Weed Science 55: 619-625.
- MS-MWS- Dorado J., Sousa E., Cahla I.M., González-Andújar J.M., Fernández-Quintanilla C. -2009. Predicting weed emergence in maize crops under two contrasting climatic conditions. Weed Research, 49: 251–260.
- MS-MWS- Efron, B.- 1979. Bootstrap methods: another look at the jackknife. Ann. Statist. 7:1–26.
- MS-MWS- Forcella, F., R. L. Benech Arnold, R. Sanchez, C. M. Ghersa -2000. Modelling seedling emergence. Field Crop Research 67:123-139
- MS-MWS- Gardarin, A., Guillemin, J.P., Munier-Jolain, N., Colbach, N. -2010. Estimation of key parameters for weed population dynamics models: Base temperature and base water potential for germination. European Journal of Agronomy. 32. 162-168.
- PGM-MWS- ISTA -2020- – International Rules for Seed Testing. Full Issue, https://www.seedtest.org/en/international-rules-for-seedtesting-_content---1--1083.html, accessed 16. 8. 2020
- MS-MWS- Loague K., Green R.E. -1991. Statistical and graphical methods for evaluating solute transport models: overview and application J Cont Hydrol 7:51–73
- MS-MWS- Masin R., Loddo D., Gasparini V., Otto S., Zanin G.-2014. Evaluation of weed emergence model *AlertInf* for maize in soybean. Weed Science, 62: 360–369.
- MS-MWS- Masin R., Loddo D., Benvenuti S., Otto S., Zanin G. -2012. Modeling weed emergence in Italian maize fields. Weed Science, 60: 254–259.
- MS-MWS- Masin R., Loddo D., Benvenuti S., Zuin M.C., Macchia M., Zanin G.-2010. Temperature and water potential as parameters for modeling weed emergence in central-northern Italy. Weed Science, 58:216-222.
- MS-MWS- Steinmaus, S. J., Prather, T. S., Holt, J. S. -2000. Estimation of base temperatures for nine weed species. Journal of Experimental Botany. 51, 275–286.

- MS-MWS- Werle R., Sandell L.D., Buhler D.D., Hartzler R.G., Lindquist J.L. -2014. Predicting emergence of 23 summer annual weed species. Weed Science, 62: 267–279.
- MS-MWS- Wiese, A. M., Binning, L. K. -1987. Calculating the threshold temperature of development for weeds. Weed Science 35, 177-179.
- MS-MWS- Wilkerson G.G., Wiles L.J. i Bennett A.C. -2002. Weed management decision models: pitfalls, perceptions and possibilities of the economic threshold approach. Weed science, 50:411-424
- MS-MWS- Washitani, I. i Takenaka, A. -1984. Mathematical description of the seed germination d ependency on time and temperature. Plant Cell Environ. 7, 359–362

Number of classes (hours)

Lectures	Student research work:	Other activites (preparation for exam, literature research, preparation of seminar et):
20	-	55

Teaching methods: PPT presentation, other didactics tools, demonstration in field and laboratory, seminars

Evaluation (max. 100 points)

Pre-exam obligations	Points	Final exam	Points
Activity during lectures =(active calls participation)	15	**Written exam**	20
Practical classes (Practical work)	15	**Oral**	20
Colloquium (=preliminary exam)			
Seminar papers =(Seminar (s))	30		

A way to form a final grade
Final grade – formed based on the sum of acquired ponts, with the minimum of 11/20 required points for both written and oral exam.

Course title		Invasive Plant Species	
Course code		IPS	
Course leader		Sava Vrbničanin	
Responsible PI (University/Faculty/Department/Country)		University of Belgrade, Faculty of Agriculture Department of Phytomedicine (Pesticides and Weed Science)	
Additional course leaders (University/Faculty/Department/Country)		Mirha Djikic (UNSA), Renata Baličević (FAZOS), Maja Šćepanovic (FAZ), Bojan Konstantinović (UNS), Danijela Petrović (SVEMO)	
Credits (ECTS)	**4**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	Acquiring knowledge about of essencial elements and consequences of biological invasions in the ecosystem, the biological-ecological and genetic potential of invasive alien plant species (IAP) with special emphasis on weeds species, introduction pathways and the status of IAP after introduction, invasive processes of introduced alien plant species, damage from IAP with special emphasis on weeds species in the newly edgy environment, prediction systems, monitoring and		

	control of IAP (with special emphasis on weed in arable lands), and lists of IAP. The students should be trained: for professional communication, collaboration and apply team work methods, develop critical thinking about the course content, also be able to present the knowledge acquired in this course, develop of skills for managing of IAP, problem solving, monitor and control of IAP, as well as build capacity to transfer knowledge into practice.
Learning outcomes	At the end of the course, the student needs to show knowledge and understanding: (1) biological, ecological and genetic potential of IAP (weeds), (2) understanding and application of keys for determination of IAP, (3) understanding of principles of the mapping of IAP, (4) acquire skills to map of IAP on arable and non-arable lands, (5) ability to predict, monitor and control of IAP (especial of weeds), (6) develop critical thinking about the course content and be able to present the knowledge acquired in this course.
Course content	
Thematic units	Theoretical teaching 1. The causes and consequences of biological invasions; 2. Biological, ecological and genetic potential of IAP; 3. Pathways of in supply of alien plant species; 4. Status of alien plant species after introduction in the new environment; 5. Invasive processes in alien plant species in an introduced environment; 6. Impact of IAP on biodiversity of indigenous flora and vegetation; 7.Damage from IAP especially on agro-ecosystem; 8. Strategies for predicting, monitoring and management of IAP, especially of weeds on arable lands.

	Practical classes 1. Overview of IAP in Europe, especially in South-East Europe; 2. Morphology, reproduction and ecology of IAP; 3. Methods for predicting and monitoring of IAP; 4. Methods for mapping IAP; 5. Methods for management of IAP, especially for weeds on agro-ecosystem.

Theoretical lessons: PPT presentations.

Practical lessons: Demonstrations in field, practical work in laboratory.

Literature and other learning material

1. Inderjit (Ed.) : Weed Biology and Management. Springer Science + Business Media B.V., 2004.
2. Inderjit (Ed.): *Invasive Plants: Ecological and Agricultural Aspects*. Birkhäuser Verlag, Basel, Boston, Berlin, 2005.
3. Inderjit (Ed.): *Management of Invasive Weeds*. Springer Science + Business Media B.V., 2009.
4. Janjić, V., Vrbničanin, S. (Eds.): Ragweed. Weed Science Society of Serbia, Belgrade (in Serbian), 2007.
5. Radosevich, S.R., Holt, J.S., Ghersa, C.M.: *Ecology of weeds and invasive plants. Relationship to agricultural and natural resource management*. Wiley-Intescience, New Jersey, 2007.
6. Vrbničanin, S. (Ed.): *Invasive weeds: invasion processes, ecological and genetic potential, introduction, prediction, risks, spread, damage and mapping.* Weed Science Society of Serbia, Belgrade (in Serbian), 2015.
7. Ward, M.S., Gaskin, F.J., Wilson, M.L.: Ecological Genetics of Plant Invasion: What Do We Know? Invasive Plant Science and Management, 1: 98-109, 2008.
8. Ward, S.: Genetic analysis of invasive plant populations at different spatial scales. Biological Invasions, 8: 541-552, 2006.

Number of classes (hours)

Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**

30 hours		70 hours
Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars		
Evaluation (max. 100 points)		

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures	10	**Written**	30
Practical classes	15	**Oral**	25
Colloquium	-		
Seminar papers	20		

A way to form a final grade

Final grade - formed based on the sum of acquired points, with the minimum of 16/20 required points for written and 13/20 for oral exam.

Focus area 6: Mycotoxins and food safety

Course title	Mycotoxins and food safety
Course code	MFS
Course leaders	Prof. Dimitris Tsitsigiannis (AUA); Dr. Donato Gerin (UNIBA)
Responsible PI (University/Faculty/Department/Country	• Agricultural University of Athens / Faculty of Crop Science/Department of Phytopathology/Greece (AUA) • University of Bari /Department of Soil, Plant and Food Sciences /Italy(UNIBA)

Other teachers and related PIs (University/Faculty/Department/Country)		1. **Magdalena Cara**, Prof., Agricultural University of Tirana, Albania 2. **Ferenc Bagi,** Prof. University of Novi Sad, Serbia 3. **Karolina Vrandecic**, Prof., University of Osijek, Croatia 4. **Nataša Duduk,** Assoc. Prof., University of Belgrade, Serbia 5. **Anita Lalić**, Assist. Prof., University in Mostar, Bosnia and Herzegovina 6. **Simona Sanzani** (UNIBA) 7. **Ivana Vico** (UB) 8. **Jelena Latinović** (UoM) 9. **Mila Grahovac** (UNS) 10. **Eleni Tsiplakou** (AUA)	
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	The aim of the course is to provide students with advanced skills on detection of mycotoxigenic fungi and mycotoxins, and on mycotoxin pre-harvest or post-harvest management strategies. The course provides the following competences: • Advanced skills on detection of mycotoxigenic fungi and mycotoxins • Advanced skills on molecular identification of mycotoxigenic fungi • Skills on designing mycotoxin pre-harvest or post-harvest management strategies • Skills on developing mycotoxin risk management strategies • Capability to recognize and manage mycotoxin contamination • Skills on rapid and analytical methods for mycotoxin assessment in the Food Chain • Skills to preventing mycotoxin contamination on field		

	• Knowledge on mycotoxin prediction modeling and smart Decision Support Systems • Opportunities to develop entrepreneurship skills create start-up companies • Opportunities to find jobs in Research labs, Food Industry, Academia, Plant Protection Product Companies, Farmers' Advisor
Learning outcomes	• **Define** the terms food safety, food poisoning, food hazard and mycotoxins • **Identify** and **describe** the present worldwide status on mycotoxin contamination in food and feed • **Identify** what might happen if mycotoxin hazards are not controlled • **Recognise** the importance of reporting food safety hazards regarding mycotoxins and the importance of implementing procedures to control mycotoxins • **Define and demonstrate** the methodology of classical, molecular and chemical identification of mycotoxigenic fungi • **Define and describe** the mycotoxin risk assessment and the epidemiology of mycotoxigenic fungi at pre- and post-harvest level • **Design** experiments based on the epidemiology of mycotoxigenic fungi • **Describe** the classical and new methods on the identification of mycotoxins in food and feed • **Describe and analyze** mycotoxin prediction modeling at pre- and post-harvest level of food production • **Develop** smart integrated pest management approach to prevent mycotoxins • **Collect and analyze** data from the experimentation on mycotoxins management strategies • **Identify** the costs of poor food safety practices to a business
Course content:	
Theoretical lessons: • Introduction to food safety	

- Introduction to mycotoxins and food safety biological hazards : Risks in plant, animal and human systems
- Mycotoxigenic fungi and their associated mycotoxins
    - Advanced molecular and chemotypic studies on identification of mycotoxigenic fungi
- Diseases of mycotoxigenic fungi in plants
- Epidemiology of mycotoxigenic fungi
    - Studies on epidemiology of mycotoxigenic fungi
- Risk assessment of mycotoxins in field, storage, human and animal
- Prevention and control measures and post-harvest strategies to manage mycotoxins
    - Experimentation on mycotoxins management strategies
- Sampling of mycotoxigenic fungi and mycotoxins
- Rapid and analytical methods for mycotoxin assessment in the Food Chain
    - TLC, ELISA, Strip Tests, Biosensors, HPLC, LC-MS/MS
- Regulations and legislation about mycotoxins
- Current trends in mycotoxin research
    - Mycotoxin prediction modeling at pre- and post-harvest level of food production
    - Smart integrated mycotoxin management (robotics, smart sprayers)
    - Decision Support Systems on mycotoxins

Practical lessons

- Diagnosis of diseases caused by mycotoxigenic fungi (symptoms, signs)
- Morphological, cultural and toxigenic characteristics of mycotoxigenic fungal species
- Molecular techniques of mycotoxigenic fungi identification
- Learning skills and techniques for detection of mycotoxins in food and feed

Literature and other learning material :

Books:

1. Food Safety & Mycotoxins, Aibo Wu (Editor) 1st ed. 2019 Edition
2. The Mycotoxin Blue Book, Duarte Diaz (Editor), 2005
3. Mycotoxins: Risks in Plant, Animal, and Human Systems (Task Force Report, Council for Agricultural Science and Technology, No. 139, January 2003)
4. Mycotoxins in Feed and Food Chain: Mycotoxins in Feed and Food Chain, Filippo Rossi (Editor), 2020

5. Nanomycotoxicology: Treating Mycotoxins in the Nano Way. Mahendra Rai (Editor), Kamel A. Abd-Elsalam (Editor) 1st Edition, 2019.
6. Mycotoxin Protocols (Methods in Molecular Biology (157). Mary W. Trucksess and Albert E. Pohland. 2000
7. Fusarium: Mycotoxins, Taxonomy and Pathogenicity. Lukasz Stępień (Editor), 2020
8. Novel Approaches to Minimising Mycotoxin Contamination. Mar Rodríguez Jovita (Editor), Félix Núñez (Editor). 2020
9. Aspergillus-Derived Mycotoxins in the Feed and Food Chain. Pócsi, I., Logrieco, A. F., Giacometti, F., Ambrus, Á., eds. (2021). eBook. Frontiers Media SA. doi: 10.3389/978-2-88966-326-2

Review papers:

1. Chen Y, Kistler HC, Ma Z. Fusarium graminearum Trichothecene Mycotoxins: Biosynthesis, Regulation, and Management. Annual Review Phytopathology 2019 Aug 25;57:15-39. doi: 10.1146/annurev-phyto-082718-100318.
2. Marin S, Ramos AJ, Cano-Sancho G, Sanchis V. Mycotoxins: occurrence, toxicology, and exposure assessment. 2013. Food Chem Toxicol. 60:218-37. doi:10.1016/j.fct.2013.07.047.
3. Pleadin J, Frece J, Markov K. Mycotoxins in food and feed. Adv Food Nutr Res. 2019; 89:297-345. doi: 10.1016/bs.afnr.2019.02.007.
4. Munkvold GP. 2017 Fusarium Species and Their Associated Mycotoxins. Methods Mol Biol. 1542:51-106. doi: 10.1007/978-1-4939-6707-0_4.
5. Perincherry L, Lalak-Kańczugowska J, Stępień Ł. Fusarium-Produced Mycotoxins in Plant-Pathogen Interactions. Toxins (Basel). 2019 Nov 14;11(11):664. doi: 10.3390/toxins11110664.
6. Ben Taheur F, Kouidhi B, Al Qurashi YMA, Ben Salah-Abbès J, Chaieb K. 2019. Biotechnology of mycotoxins detoxification using microorganisms and enzymes. Toxicon. Mar 15;160:12-22. doi: 10.1016/j.toxicon.2019.02.001.
7. Kabak B, Dobson AD. Mycotoxins in spices and herbs-An update. 2017. Crit Rev Food Sci Nutr. Jan 2;57(1):18-34. doi: 10.1080/10408398.2013.772891.
8. Ayofemi Olalekan Adeyeye S. Aflatoxigenic fungi and mycotoxins in food: a review. 2020. Crit Rev Food Sci Nutr.; 60(5):709-721. doi: 10.1080/10408398.2018.1548429.
9. Fusarium Molds and Mycotoxins: Potential Species-Specific Effects. 2018. Bertero A, Moretti A, Spicer LJ, Caloni F. Toxins (Basel). Jun 15;10(6):244. doi: 10.3390/toxins10060244.

10. Nolan P, Auer S, Spehar A, Elliott CT, Campbell K. 2019. Current trends in rapid tests for mycotoxins. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 36(5):800-814. doi: 10.1080/19440049.2019.1595171.
11. Perrone G, Gallo A. 2017. Aspergillus Species and Their Associated Mycotoxins. Methods Mol Biol. 1542:33-49. doi: 10.1007/978-1-4939-6707-0_3.
12. Pinto VE, Patriarca A. A. 2017. lternaria Species and Their Associated Mycotoxins. Methods Mol Biol. 2017;1542:13-32. doi: 10.1007/978-1-4939-6707-0_2.
13. Freire L, Sant'Ana AS. 2018. Modified mycotoxins: An updated review on their formation, detection, occurrence, and toxic effects. Food Chem Toxicol. 111:189-205. doi: 10.1016/j.fct.2017.11.021. Epub 2017 Nov 20.
14. Berthiller F, Crews C, Dall'Asta C, Saeger SD, Haesaert G, Karlovsky P, Oswald IP, Seefelder W, Speijers G, Stroka J. 2013. Masked mycotoxins: a review. Mol Nutr Food Res. 2013 Jan;57(1):165-86. doi: 10.1002/mnfr.201100764.

Number of classes :

Lectures (teoretical , practical lessons, seminars = contact hours):	Student research work:	Other activities (preparation for exam, literature research, preparation of seminars etc):
20	**-**	**55**

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade is formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

University of Zagreb Faculty of Agriculture
Svetosimunska street 25, 10000 Zagreb, Croatia
Contact: harissa@agr.hr
www.agr.hr

Focus area 7: General contents of transversal interest

Course title		Biodiversity and bioindicators in sustainable agriculture	
Course code		BD&BI	
Course leader		Prof.dr.sc. Mirjana Brmež, course leader	
Responsible PI (University/Faculty/Department/Country)		Faculty of Agrobiotechnical sciences in Osijek, University of J.J. Strossmayer in Osijek, Croatia	
Additional course leaders (University/Faculty/Department/Country)		Tiziana Mascia (UNIBA) , Darija Lemić (FAZ), Dragana Božić (UB), Nataša Duduk (UB), Claudio De Giovanni (UNIBA), Shpend Shahini (AUT), Aleksandra Petrović (UNS)	
Credits (ECTS)	**3**	**Course status**	ELECTIVE
Specific entry requirements	none		
Aim of the course and students` competences	The aim of this subject is to integrate the knowledge about biodiversity and bioindicators as well as to manage the practices which will contribute to sustainability of agriculture. The course provides students with the following competences: Critical thinking about importance of biodiversity for vital functions of soil ecosystem health; Communication about main reasons of biodiversity loss and solving problems in sustainable agriculture; Managing appropriate bioindicators to access soil health and calculate ecological indices.		

Learning outcomes	1. Justify the biodiversity contribution to sustainability of ecosystem 2. Define the major causes of biodiversity loss 3. Compare interspecific interaction types in ecosystem communities 4. Select keystone species as bioindicators based on biodiversity pattern 5. Measure ecological indices based on biodiversity and bioindicators 6. Interpret specific responses to disturbance in ecosystem based on biomarkers 7. Chose appropriate agricultural systems and practices that enhance biodiversity 8. Valorize the resistance of the plant to phytopathogenic agents” 9. 9. Assess ecological habitat conditions based on weeds as bioindicator.

Course content	
Thematic units	6. Topic - Biodiversity and ecosystem health (Brmez, M.) subtopics: population, community, ecosystem, succession, ecosystem services subtopics: methods of measuring biodiversity (simple methods vs. laboratory methods) subtopics: major causes of biodiversity loss (invasive species, pollution, climate change, overharvesting, habitat alteration) 7. Topic - Biodiversity and their link to sustainability (Lemic, D.) subtopics: factors affecting biodiversity (biotic, abiotic) subtopics: interspecific interaction in communities (predation, parasitism, antibiosis, commensalism, cooperation, mutualism) 8. Topic - Bioindicators based on biodiversity (Brmez, M.) subtopics: use of bioindicators to access sustainability, characteristic of bioindicators, keystone species, ecological indices, biomarkers 9. Topic - Nematodes as bioindicators (Brmez, M.) 10. Topic – Carabids (ground beetles) and earthworms as soil quality bioindicators (Lemic, D.) 11. Topic – evaluation of a large collection of indigenous genetic resources of vegetable species to define characters of resistance to phytopathogenic agents, such as viruses, in order to reduce the use of agropharmaceuticals in the production process and to enhance local productions (T. Mascia) Subtopics: identification of local vegetable plant varieties resistant to pathogens and phytosanitary remediation and production of certified nursery material Subtopics: Grafting as a natural and sustainable strategy to manage pathogens transmitted by arthropods in vegetable crops 12. Topic-Weeds as bioindicators (Bozic, D.) 13. Seminar - student research work
Literature and other learning material	
• Wall, D. F., Nielsen, N. U., Six, J. (2015): Soil biodiversity and human health**.** Nature, vol. 528: 69-76. DOI:10.1038/nature15744.	

- Ferris, H., Toumisto, H. (2015): Unearthing the role of biological diversity in soil health**.** Soil Biology and Biochemistry, Volume 85, Pages 101-109.
- Diaz, Sandra & Tilman, D. & Fargione, Joe. (2005). Biodiversity regulation of ecosystem services. Ecosystems and Human Well-being: Current State and Trends. 297-329.
- Paoletti, G.M. (1999): Using bioindicators based on biodiversity to assess landscape sustainability. Agriculture, Ecosystems and Environment 74 (1999) 1–18.
- Wilson, D.M., Kakouli-Duarte, T. (2009): Nematodes as Environmental Indicators. DOI 10.1079/9781845933852.0000.
- Benitez, H.A., Lemić, D., Villalobos-Leiva, A., Bažok, R., Ordenes-Claveria, R., Pajač Živković, I., Mikac, K.M. (2020): Breaking Symmetry: Fluctuating Asymmetry and Geometric Morphometrics as Tools for Evaluating Developmental Instability under Diverse Agroecosystems. Symmetry, 12(11): 1789.
- Benítez, H. A., Lemic, D., Püschel, T., Virić Gašparić, H., Kos, T., Barić, B., Bažok, R., Pajač Živković, I. (2018): Fluctuating asymmetry indicates levels of disturbance between agricultural productions: An example in Croatian population of Pterostichus melas melas (Coleptera: Carabidae). Zoologischer anzeiger. 276: 42-49.
- Lemic, D., Čačija, M., Virić Gašparić, H., Drmić, Z., Bažok, R., Pajač Živković, I. (2017): The ground beetle (Coleoptera: Carabidae) community in an intensively managed agricultural landscape. Applied Ecology and Environmental Research. 15 (4): 661-674.
- Virić Gašparić, H., Drmić, Z., Čačija, M., Graša, Ž., Petrak, I., Bažok, R., Lemic, D. (2017): Impact of environmental conditions and agro-technical factors on ground beetle populations in arable crops. Applied Ecology and Environmental Research. 15 (3): 697-711.
- Spanò R., Ferrara M., Gallitelli D**., Mascia T**., 2020, The role of grafting in the resistance of tomato to viruses. Plants 2020, 9, 1042; doi: 10.3390/plants9081042
- Spanò R., Bottalico G., Corrado A., Campanale A., Di Franco A., **Mascia T**., 2018. A Protocol for Producing Virus-Free Artichoke Genetic Resources for Conservation, Breeding and Production. Agriculture 8, 36; doi:10.3390/agriculture8030036

- Carlesi, S., Barberi, P. (2017): Weeds as soil bioindicators: How to sample and use data. FertilCrop Technical Note. Research Institute of Organic Agriculture (FiBL) & Scuola Superiore Sant'Anna (SSSA), Frick & Pisa.
- Ramírez-Santoyo, L.F., Guzmán-Mendoza, R., Leyte-Manrique, A., et al. (2021): Weed plants used as bioindicators of special soil characteristics. Horticulture International Journal. 5(1):21-23.

Number of classes (hours) - 20 hours teaching lessons, 5 hours seminar

Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
20	-	55

Teaching methods: PPT presentations, other didactic tools, demonstrations in field and laboratory , seminars /round tables/workshops

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures	20	**Written**	60
Practical classes		**Oral**	
Colloquium			
Seminar papers	20		

A way to form a final grade

Final grade - formed based on the sum of acquired points, with the minimum of 30/60 required points written exam.

Course title		GIS & Spatial Data Analysis	
Course code		GIS & SDA	
Course leader		Melisa Ljuša (UNSA)	
Responsible PI (University/Faculty/Department/Country		University of Sarajevo/ Faculty of Agriculture and Food Sciences/ Institute of Soil, Agrochemistry and melioration/ Bosnia and Herzegovina	
Other teachers and related PIs (University/Faculty/Department/Country)		Ivan Plašćak (FAZOS); Goran Topisirović (UB), University of Osijek/Faculty of Agriculture/ Department of Agricultural Engineering/Croatia University of Belgrade/ Faculty of Agriculture/ Institute of Agricultural Engineering/ Serbia	
Credits (ECTS)	**3**	**Course status**	Elective
Specific entry requirements	none		
Aim of the course and student `s competences	To enable students to achieve: a. Knowledge and understanding of: possibilities and importance of application of GIS and precision agriculture (PA) principles, GIS and PA methods and techniques, basic GIS project working procedures, spatial data infrastructure and visualization, data bases structure, functional connecting of spatial data and corresponding data bases, possibilities of the results analysis and visual presentation. b. Skills of: GIS applications in practice, selection and collecting attributes for data base, spatial data mapping and visualization, applications of principles of precision agriculture, GIS applications as a tools for precision agriculture.		
Learning outcomes	At the end of the course students should show a thorough understanding and knowledge on possibilities and importance of application of GIS and precision agriculture (PA) principles, GIS and PA methods and techniques, basic GIS project working procedures, spatial data infrastructure and visualization, data bases structure, functional connecting of spatial data and corresponding data bases, possibilities of analysis and visual presentation of the results.		

Course content:

Theoretical lessons

1. Introduction in GIS and SDA
2. Possibilities of GIS application in agriculture
3. GI Systems and application of SD visual presentations
4. Data bases
5. Spatial Data mapping
6. Spatial Data analysis
7. Results presentation

Practical lessons

- Exercises
- Discussions
- Problem solving
- Study and research work

Literature and other learning material:

1. Pierce, F.J., Clay, D. 2007. GIS Applications in Agriculture. CRC Press. Taylor and Francis Group. Boca Raton, USA.
2. Brase, A.T. 2006. Precision Agriculture. Thomson Delmar Learning, Clifton Park New York, USA.
3. Burrough, A.P., McDonnel, A.R. 2000. Principles of Geographical Information Systems. Oxford University Press Inc., New York. USA.
4. Heywood, I., Cornelius, Sarah, Carver, S. 1998. An Introduction to Geographical Information Systems. Pearson Education Limited, Essex, England.
5. Longley, A.P., Goodchild, F.M., Maguire, J.D., Rhind, W.D. 2001. Geographic Information Systems and Science. John Wiley and Sons, Ltd. Chichester, England.
6. Lojo, A., Ponjavić, M. 2004. GIS u gazdovanju prirodnim resursima. Gauss d.o.o. Tuzla. Bosna i Hercegovina.
7. Чукалиев, О., Вукелић Шутоска, Марија, Арнаудова, Жулиета, Иванов, И. 2005. Геоматски техники во земјоделството. Медиана д.о.о. Скопје. Македонија.
8. Ormsby, T., Napoleon, E., Burke, R., Groess, Carolyn, Feaster, Laura. 2001. Getting to Know ArcGIS desktop. ESRI Press. Redlands, California.
9. Taletović J., Pleho N., Ljuša M. 2018. GIS u prostornom planiranju. Sarajevo. Bosna i Hercegovina.

10. Ključanin S., Poslončec-Petrić V., Bačić Ž. 2018. Osnove Infrastrukture prostornih podataka. Dobra knjiga. Sarajevo. Bosna i Hercegovina.

Recommended Internet sites.

Number of classes		
Lectures (teoretical, practical lessons, seminars = contact hours): 20	**Student research work:** -	**Other activities (preparation for exam, literature research, preparation of seminars etc.): 55**

Teaching methods: PPT presentations, practical exercises in GIS laboratory, seminar

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	15	**Written exam**	20
Practical classes (= Practical work)	15	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title		Principles of Scientific Work in Bio-science	
Course code		PSWB	
Course leader		Franco Nigro (UNIBA)	
Responsible PI (University/Faculty/Department/Country)		University of Bari /Department of Soil, Plant and Food Sciences /Italy (UNIBA)	
Other teachers and related PIs (University/Faculty/Department/Country)		Antonio Ippolito (UNIBA), Sava Vrbničanin (UB),	
Credits (ECTS)	**3**	**Course status**	Mandatory
Specific entry requirements	NONE		

Aim of the course and student `s competences	The main objectives of this course are i) to learn the principles of thinking, working, and communicating the results at a scientific level; ii) to introduce the theory of science and knowledge, and the role of the researcher within society. Moreover, the course will provide knowledge and understanding about research ethics, systematic information-seeking, and scientific communication in the Plant Health context.
Learning outcomes	After the course student will be able i) to know the classical theory of science and the development of theories; ii) to explain the theoretical and philosophical bases in the choice of research design related to the specific research field; ii) to demonstrate familiarity with data processing: open data and open access; iii) to discuss, in a critical manner, the different types of scientific communication and publication processes/models in the Plant Health context.

Course content:

Theoretical lessons: 1) What is science; 2) Making accurate observations; 3) Proposing and testing explanations; 4) Establishing causal links; 5) Fallacies in the name of science; 6) Science's powers and limits; 7) Research ethics and the integrity of the researcher; 8) Science and society: an overview; 9) Images of science: a reality check; 10) Plant Health Science in the social contexts; 11) Communicating the science; 12) Biobanks and ethics committees; 13) Transition to open science; 14) Open science in an open society; 15) The citizen science and the plant health.

Practical lessons:

Illustration of the applicability and the pitfalls of the general principles of "scientific method", and the communication of the Plant Health Science. The case of epidemic's quarantine plant pathogens. Case studies: *Xylella fastidiosa* subsp*. pauca/*olive tree; CTV/citrus; other cases suggested by the students.

Literature and other learning material:

1. Carey S.S. (2011). A Beginner's Guide to Scientific Method. Wadsworth Publishing.
2. Palazzani L. (2019). Innovation in Scientific Research and Emerging Technologies: A Challenge to Ethics and Law. Springer. https://doi.org/10.1007/978-3-030-16733-2
3. Miedema F. (2021). Open Science: The Very Idea https://doi.org/10.1007/978-94-024-2115-6
4. Vohland K., Land-Zandstra A., Ceccaroni L., Lemmens R., Perelló J., Ponti M., Samson R., WagenknechtK.., Eds. (2021). The Science of Citizen Science. Springer. https://doi.org/10.1007/978-3-030-58278-4

Number of classes		
Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**
20	**-**	**55**

Teaching methods: PPT presentations, other didactic tools, seminars, and round tables.

Evaluation (max. 100 points)

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	10	**Written exam**	20
Practical classes (= Practical work)	20	**Oral exam**	20
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	30		

A way to form a final grade:

Final grade is formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.

Course title	Bio-informatics		
Course code	BINF		
Course leaders	Jasmin Grahić (UNSA), Arnela Okić (UNSA)		
Responsible PI (University/Faculty/Department/Country	University of Sarajevo, Faculty of Agriculture and Food Sciences		
Other teachers and related PIs (University/Faculty/Department/Country)	Ivana Stanković (UB) University of Belgrade, Faculty of Agriculture Mladen Petreš (UNS) University of Novi Sad, Faculty of Agriculture		
Credits (ECTS)	**3**	**Course status**	Mandatory
Specific entry requirements	none		

Aim of the course and student `s competences	The aim of the course is to provide fundamental knowledge on bioinformatics for the analyses of sequences and genomes of different target organisms in plant health studies. Upon completion of the course the student will be able to independently analyze biological data with adequate bioinformatic tools and communicate obtained results.
Learning outcomes	• knowledge and awareness of the basic principles of bioinformatics in plant health studies; • student will be able to use existing software effectively to extract biological information and solve problems in different fields of interest; • be able to visualize and communicate scientific findings.

Course content:

Theoretical lessons:

1) Introduction to Bioinformatics, R and RStudio
2) Bioinformatics Databases
3) BLAST programs
4) Reading sequences in R and Sequence Alignment
5) Data analysis and visualization with the focus on Molecular Phylogenetics
6) Analysis of Gene Expression

Practical lessons:

1) BLAST
2) Reading sequences in R and Sequence Alignment
3) Data analysis and visualization with the focus on Molecular Phylogenetics
4) Analysis of Gene Expression

Literature and other learning material:

1) Curry, E. (2020). Introduction to Bioinformatics with R - A Practical Guide for Biologists. Chapman and Hall/CRC, ISBN: 9781138495715.
2) Baum, D.A., Smith, S.D. (2012). Tree Thinking: An Introduction to Phylogenetic Biology. W. H. Freeman, 1st edition, ISBN-10: 1936221160.
3) Coghlan, A. (2011). A Little Book of R For Bioinformatics (http://media.readthedocs.org/pdf/a-little-book-of-r-for-bioinformatics/latest/a-little-book-of-r-for-bioinformatics.pdf).

<table>
<tr><td colspan="4">4) Kalamujic Stroil, B., Doric, S., Lukic Bilela, L., Pojskic, N. (2018). Aplikativna bioinformatika – Praktikum. Univerzitet u Sarajevu – Institut za genetičko inženjerstvo i biotehnologiju.</td></tr>
<tr><td colspan="4">Number of classes:</td></tr>
<tr><td>Lectures (theoretical, practical lessons, seminars = contact hours):</td><td colspan="2">Student research work:</td><td>Other activities (preparation for exam, literature research, preparation of seminars etc.):</td></tr>
<tr><td>20</td><td colspan="2">-</td><td>55</td></tr>
<tr><td colspan="4">Teaching methods: seminar, demonstration, PBL</td></tr>
<tr><td colspan="4">Evaluation (max. 100 points)</td></tr>
<tr><td>Pre-exam obligations</td><td>Points</td><td>Final exam</td><td>Points</td></tr>
<tr><td>Activity during lectures (=active class participation)</td><td>15</td><td>Written exam</td><td>20</td></tr>
<tr><td>Practical classes (= Practical work)</td><td>15</td><td>Oral exam</td><td>20</td></tr>
<tr><td>Colloquium (= preliminary exam)</td><td></td><td></td><td></td></tr>
<tr><td>Seminar papers (=Seminar(s))</td><td>30</td><td></td><td></td></tr>
<tr><td colspan="4">A way to form a final grade:
Final grade - formed based on the sum of acquired points, with the minimum of 11/20 required points for both written and oral exam.</td></tr>
</table>

<table>
<tr><td>Course title</td><td colspan="3">Knowledge and management of research funding systems</td></tr>
<tr><td>Course code</td><td colspan="3">KMRFS</td></tr>
<tr><td>Course leader</td><td colspan="3">Prof. dr. sc. Renata Bažok</td></tr>
<tr><td>Responsible PI (University/Faculty/Department/Country)</td><td colspan="3">FAZ</td></tr>
<tr><td>Other teachers and related PIs (University/Faculty/Department/Country)</td><td colspan="3">Prof. dr. sc. Nedeljko Latinović/ UoM</td></tr>
<tr><td>Credits (ECTS)</td><td>4</td><td>Course status</td><td>Mandatory</td></tr>
</table>

Specific entry requirements	none
Aim of the course and student `s competences	Acquiring knowledge and understanding of the principles on research funding systems in life sciences: how to find grants, overview of how to plan project, how to write a high quality project proposal, and how to manage project during its life time. Students will get knowledge on data management and intellectual property rights protection.
Learning outcomes	• Identify and describe the principles of research funding systems; • Recognize how to find sources for funding and identify eligibility in relation to the basic requirements of particular call; • Use appropriate strategies to develop project application and define project objectives, project outputs and project results. that are in accordance to the call; • Develop all basic elements needed for successful project application; • Propose effective budget in accordance to funding rules of the call. • Choose and use appropriate project management software. • Identify type of intellectual property and choose appropriate way to protect intellectual property.

Course content:
Theoretical lessons: The principles of research funding systems; Eligibility criteria and their importance; Pertinence of the project objectives with the call; How to develop key performance indicators; Basic elements of the project application: Overall objective, specific objectives, project outputs, deliverables, milestones, Ghant chart, High Level Process Map, Project charter, Data Management Plan, Implementation plan; Risk and mitigation measures; Sustainability issues; Basic elements of the project budget; Project management software; Principles of project evaluation; Ethical aspects of research -EU Charter for researchers; Intelectual property rights; *Practical lessons* Training and preparation in writing project proposal; Evaluation of the project- use of evaluation grid; Preparation of the project report; Using appropriate project management software. Preparation of the plan for IPR protection.
Literature and other learning material :
1. Wingate, L. M. Project Management for Research and Development (Best Practices in Portfolio, Program, and Project Management) 1st Edition, 2015.CRC Press, Taylor& Francis Group, Boca Raton, FL, USA. 2. Broadbent, K.P. 1994. Project Management Manual. International Research Development Centre, Ottawa, Canada. Available at: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/36800/IDL-36800.pdf?sequence=1 3. Franko, M., Ionescu-Pioggia, M. 2006. Making Right Moves: A Practical Guide for Scientific Management. Howard Hughes Medical Institute and Burroughs Welcome Fund. Available at: http://www.hhmi.org/labmanagement 4. 4. McGovern, V. 2009. Excellence Everywhere. Burroughs Welcome Fund. Available at: www.excellenceeverywhere.org
Number of classes 30 hours of lectures and seminars, 70 hours of other activities

Lectures (teoretical , practical lessons, seminars = contact hours):	**Student research work:**	**Other activities (preparation for exam, literature research, preparation of seminars etc):**

10 hours direct lectures and 20 hours seminars	**-**	**70 hours**

Teaching methods: PPT presentations, other didactic tools, web based demonstrations, seminars /round tables/workshops

Evaluation (max. 100 points) Class attendance and activity 10 points, Oral exam 45 points, seminar I 30 points, seminar II 15 points

Pre-exam obligations	**Points**	**Final exam**	**Points**
Activity during lectures (=active class participation)	10	**Written exam**	
Practical classes (= Practical work)		**Oral exam**	45
Colloquium (= preliminary exam)			
Seminar papers (=Seminar(s))	45 (30+15)		

A way to form a final grade:

60 points must be achieved. Out of them 27 points from oral exam, 27 points from seminars (15+12) and 6 points from class attendance.

0-59- not passed

60-69 – fair

70-82- good

83-91 – very good

92-100- excellent