Sveučilište u Zagrebu Agronomski fakultet
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Innovative Systems in Controlled Environment Agriculture (CEA) for Vegetable and Medicinal Plant Production (296630)

Nositelj kolegija

izv. prof. dr. sc. Sanja Radman

Opis kolegija

The course is structured into four thematic modules covering the principles, technologies, production systems, and sustainability aspects of Controlled Environment Agriculture (CEA) in vegetable and medicinal plant production.

Module 1: Foundations of Sustainable and Controlled Environment Production
Fundamental principles of CEA, sustainable production, environmental control, and resource efficiency in vegetable and medicinal plant production.

Module 2: CEA Infrastructure and Technological Systems
Greenhouse structures, growth chambers, environmental control, automation, IoT, irrigation, lighting, heating, ventilation, and sensor technologies.

Module 3: Advanced CEA Production Systems
Vertical farming, hydroponic and soilless cultivation, microgreens production, and crop management under controlled conditions, including practical exercises.

Module 4: Sustainable Energy and Resource Management in CEA
Photovoltaic systems, energy efficiency, circular economy, and sustainable management and valorisation of agricultural and food-system bio-waste.

The course combines lectures, seminars, practical exercises, and fieldwork. Practical activities include establishing and managing hydroponic systems, sowing and cultivating crops and microgreens, monitoring environmental parameters, and evaluating crop performance. Seminars involve discussions, problem-based tasks, academic debates, and student presentations.

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ECTS: **6.00**

Sati nastave: 60
Predavanja: 44
Vježbe u praktikumu: 4
Seminar: 8
Terenske vježbe: 4

Izvođač predavanja

- izv. prof. dr. sc. Sanja Radman
- prof. dr. sc. Božidar Benko
- prof. dr. sc. Sanja Fabek Uher

Izvođač vježbi

- prof. dr. sc. Božidar Benko
- dr. sc. Nevena Opačić

Izvođač seminara

- izv. prof. dr. sc. Sanja Radman
- dr. sc. Nevena Opačić

Ocjenjivanje

Dovoljan (2): 60–70%
Dobar (3): 71–80%
Vrlo dobar (4): 81–90%
Izvrstan (5): 91–100%

Vrsta kolegija

- Graduate studies / Environment, agriculture and resource management (Izborni kolegij, 2. semestar, 1. godina)

Opće kompetencije

The objective of this course is to provide students with advanced knowledge and practical skills in Controlled Environment Agriculture (CEA), with a focus on sustainable production of vegetables and medicinal plants. Students will learn to:
1. Understand fundamental concepts, technologies, and system designs used in CEA.
2. Apply scientific and technological methods for planning, managing, and optimizing CEA systems.
3. Evaluate the efficiency, advantages, limitations, and risks associated with different CEA systems.
4. Manage agronomic practices, including abiotic stress management, to enhance bioactive compounds.
5. Critically evaluate and develop strategies to optimize the cultivation of vegetable crops, medicinal plants, and microgreens under controlled conditions, with emphasis on their nutritional and functional properties.

Oblici nastave

- Lectures
- Field work
- Seminars
- Exercises

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Ishodi učenja i način provjere

Ishod učenja	Način provjere
1. Critically analyze, synthesize, and evaluate key concepts, advanced technologies, and integrated system designs used in Controlled Environment Agriculture (CEA), with the ability to apply them in complex and novel contexts.	Written exam; seminar/presentation; analysis of case studies
2. Apply scientific and technological methods to plan, operate, and manage CEA systems.	Practical exercises; project work; written exam
3. Compare different CEA systems and evaluate their efficiency, advantages, limitations, and production risks.	Written exam; case study analysis; seminar/presentation
4. Manage agronomic practices, including drought and salinity stress, to improve crop quality and content of bioactive compounds.	Practical exercises; project work; written exam
5. Critically assess and propose optimization strategies for microgreens and medicinal plant production under controlled conditions, considering nutritional and functional properties.	Project work; practical exercises; seminar/presentation

Način rada

Obveze nastavnika

Preparation and delivery of lectures and practical exercises, supervision of student activities, provision of learning materials, assessment of student work, and consultation with students.

Obveze studenta

Students are expected to:
• Attend all lectures, seminars, practical exercises, and fieldwork.
• Prepare seminars and deliver oral presentations.
• Complete written tests and other forms of assessment throughout the course.

Polaganje ispita

Elementi praćenja	Maksimalno bodova ili udio u ocjeni	Bodovna skala ocjena	Ocjena	Broj sati izravne nastave	Ukupni broj sati rada prosječnog studenta	ECTS bodovi
Class attendance				51	51	1,7
Test 1	40%	<60% 60-70% 71-80% 81-90% 91-100%	Nedovoljan (1) Dovoljan (2) Dobar (3) Vrlo dobar (4) Izvrstan (5)	25	45	1,5
Test 2	40%	<60% 60-70% 71-80% 81-90% 91-100%	Nedovoljan (1) Dovoljan (2) Dobar (3) Vrlo dobar (4) Izvrstan (5)	2	45	1,5

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Elementi praćenja	Maksimalno bodova ili udio u ocjeni	Bodovna skala ocjena	Ocjena	Broj sati izravne nastave	Ukupni broj sati rada prosječnog studenta	ECTS bodovi
Seminar essay	20%	<60% 60-70% 71-80% 81-90% 91-100%	Nedovoljan (1) Dovoljan (2) Dobar (3) Vrlo dobar (4) Izvrstan (5)	5	39	1,3
Total	100%	(T1×0,4)+(T2×0,4)+ (S×0,2) = final grade		60	180	6

Students will be evaluated through two mid-term tests, a written exam, and a seminar essay.
Mid-term tests (2): 80% of the final grade (40% each)
Seminar essay: 20% of the final grade

Elementi praćenja	Opis	Rok	Nadoknada
Seminar essay	Subject matter and content quality – 40% Use and appropriate citation of relevant literature – 20% Structure and clarity of the essay – 20% Independent and critical treatment of the topic – 10% Language and technical quality – 10%		

Tjedni plan nastave

1. L4 Conventional vs. Sustainable Vegetable and Medicinal Plant Production - Comparison of conventional and sustainable vegetable and medicinal plant production, focusing on climate change impacts and water, carbon, and ecological footprints
2. L6 Principles of Controlled Environment Agriculture (CEA) - Introduction to CEA, its principles and objectives, and applications in urban agriculture for efficient and sustainable food production
3. L4, E2 CEA Infrastructure and Technologies - Overview of CEA infrastructure, focusing on greenhouses and growth chambers
4. L4 Smart Automation and IoT Systems in CEA - Explores automation, sensors, and IoT in CEA, including climate control, irrigation, LED lighting, heating/cooling, and monitoring plant growth parameters. Practical Exercises: Application of Sensors and Automation in CEA Systems
5. L4 Z-Farming: Zero-Acreage Vertical Farming - Overview of zero-acreage farming, vertical farm concepts, and space-efficient techniques for urban and sustainable crop production
6. L4, L4, S2 Hydroponic Cultivation Techniques - Hydroponic systems such as floating, ebb & flow, NFT, and aeroponics, highlighting methods for efficient soilless plant production. Seminar - Planning Hydroponic Crop Production in CEA: Students work in groups and are assigned a vegetable or medicinal crop to design a basic hydroponic production plan under controlled conditions. They select an appropriate system (e.g., NFT, floating, ebb & flow, aeroponics), determine sowing time and crop cycle, and outline key environmental parameters. The seminar concludes with a brief group discussion.
7. L2, L2, E2 Microgreens Production in Controlled Environments - Principles of microgreens

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cultivation, species selection, substrates, lighting, nutrient solutions, and evaluation of morphological and nutritional quality. Practical: Sowing and Cultivation of Microgreens. Hands-on practice in sowing and growing microgreens, focusing on substrates, abiotic factors, species and cultivation techniques

8. L4, S2 Crop Management in CEA - Crop management in CEA (drought and salt stress) in modern vegetable and medicinal plant production Seminar - Managing Drought and Salinity Stress in CEA Crop Production: Students work in groups and are assigned a vegetable or medicinal plant species. Each group develops a basic crop management strategy to mitigate drought and/or salt stress in a CEA system. They identify key stress risks related to the selected crop, such as sensitivity to water deficit, salinity tolerance, vulnerable growth stages, and typical physiological responses. In addition, they consider system-related factors (e.g., EC levels, irrigation regime, substrate properties, and climate conditions) that may contribute to stress development.
9. L6 Photovoltaic Systems in Controlled Environment Agriculture - Overview of solar panels, energy balance, and their integration into CEA systems for improved energy efficiency and sustainability
10. F4 Field Work - Organized as a study visit to a commercial producer applying Controlled Environment Agriculture (CEA) technologies. During the visit, students will gain direct insight into practical implementation of greenhouse, hydroponic, or vertical farming systems, observe technological solutions in real production conditions, and discuss operational, technical, and sustainability aspects with professionals in the field.
11. S4 Seminar and Project Presentation - Seminar/Project: Monitoring Hydroponic Crop Growth in CEA Students work in groups to monitor a vegetable or medicinal plant grown in a hydroponic system during the semester. They regularly measure abiotic factors (temperature, humidity, light, pH, EC), track plant growth, and record biomass at harvest. Groups analyze how environmental conditions affected growth and yield, identify stress events, and propose optimization strategies. The project concludes with a short group presentation summarizing methods, results, and conclusions.

Obvezna literatura

1. Sapounas, A., Katsoulas, N., Slager, B., Bezemer, R., & Lelieveld, C. (2020). Design, control, and performance aspects of semi-closed greenhouses. Agronomy, 10(11), 1739.
2. Zhao, S., & Song, W. (2025). Sustainable Development of Controlled Environment Agriculture. Agronomy, 15(9), 2129.
3. Vatistas, C., Avgoustaki, D. D., & Bartzanas, T. (2022). A systematic literature review on controlled-environment agriculture: How vertical farms and greenhouses can influence the sustainability and footprint of urban microclimate with local food production. Atmosphere, 13(8), 1258.
4. Benke, K., & Tomkins, B. (2017). Future food-production systems: vertical farming and controlled-environment agriculture. Sustainability: science, practice and policy, 13(1), 13-26.
5. Benko, B., Fabek Uher, S., Radman, S., Opačić, N. (2024). Hydroponic Production Systems in Greenhouses. Climate Smart Greenhouses-Innovations and Impacts. London: IntechOpen

Preporučena literatura

1. Korsa, G., Ayele, A., Haile, S., Alemu, D. (2025). Hydroponic farming: Innovative solutions for sustainable and modern cultivation technique. Hydroponic Farming-A Modern Agriculture Technique. London: IntechOpen

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