COURSE OUTLINE

1. GENERAL INFORMATION

FACULTY/SCHOOL	SCHOOL Of PLANT SCIENCES		
DEPARTMENT	CROP SCIENCE		
LEVEL OF STUDY	Pregraduate		
COURSE UNIT CODE	8	**Semester:**	4th
COURSE TITLE	PLANT NUTRITION PHYSIOLOGY		
INDEPENDENT TEACHING ACTIVITIES *in case credits are awarded for separate components/parts of the course, e.g. in lectures, laboratory exercises, etc. If credits are awarded for the entire course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHNG HOURS**	**ECTS**
Lectures		3	5
Laboratory exercises		2	
Add rows if necessary. The organization of teaching and the teaching methods used are described in detail under section 4			
COURSE TYPE *Background knowledge, Scientific expertise, General Knowledge, Skills Development*	Background knowledge Skills Development		
PREREQUISITE COURSES:	Plant Physiology Functional Plant Anatomy		
LANGUAGE OF INSTRUCTION:	Greek		
LANGUAGE OF EXAMINATION/ASSESSMENT:			
THE COURSE IS OFFERED TO ERASMUS STUDENTS	No		
COURSE WEBSITE (URL)	https://oeclass.aua.gr/eclass/courses/EFP158/		

2. LEARNING OUTCOMES

Learning Outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate (certain) level, which students will acquire upon successful completion of the course, are described in detail. It is necessary to consult:

APPENDIX A

- *Description of the level of learning outcomes for each level of study, in accordance with the European Higher Education Qualifications' Framework.*
- *Descriptive indicators for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and*

APPENDIX B

- *Guidelines for writing Learning Outcomes*

Upon successful completion of the course, students will know:

- The main physiological roles of each nutrient in the plant

• The efficiency of the use of each nutrient in the plant
and they will understand:
• The basic physiological mechanisms of uptake, transport and management of each nutrient within the plant
• How nutrients are recycled in the plant body
• The physiological basis of deficiencies
• The physiological basis of toxicities
• The interactions of each nutrient with the rhizosphere, the root system and the foliage of the plant
• How the plant modifies the properties of its rhizosphere depending on its nutritional status

During the laboratory exercises, students will gain insight into:
• How is the nutritional status of the leaf linked to selected morphological & physiological parameters of the leaf
• How is the nutritional status of the root system linked to selected morphological & physiological parameters of individual roots and their architecture
• How is a mycorrhizal relationship established in the root system, the spatial arrangement of this relationship and its contribution to the plant

General Competences

Taking into consideration the general competences that students/graduates must acquire (as those are described in the Diploma Supplement and are mentioned below), at which of the following does the course attendance aim?

Search for, analysis and synthesis of data and information by the use of appropriate technologies,	*Project planning and management*
Adapting to new situations	*Respect for diversity and multiculturalism*
Decision-making	*Environmental awareness*
Individual/Independent work	*Social, professional and ethical responsibility and sensitivity to gender issues*
Group/Team work	*Critical thinking*
Working in an international environment	*Development of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Introduction of innovative research	*(Other…….citizenship, spiritual freedom, social awareness, altruism etc.)*
	…….

- Ability to understand the nutritional status of the plant
- Ability to understand the distinct physiological roles of each nutrient
- Ability to understand the nutritional relationship between the root system, aerial part and foliage
- Ability to understand & apply the concept of the efficiency of use of each nutrient element by cultivated plants

3. COURSE CONTENT

Lectures

Introduction: The function of plant nutrition, inorganic nutrients and their forms.

The efficiency of the use of nutrients by cultivated plants: Yield and fertilizers, nutrient response curves, efficient use of nutrients by cultivated plants, uptake and utilization efficiency, harvest indices and nutrient distribution, perspectives.

I. Physiological roles of nutrients

Nitrogen: Nitrogen uptake and movement, nitrate transport in the vacuole, nitrate efflux, ammonium transporters, ammonium uptake by roots, ammonia transport in the vacuole, plastid transport, amino acid transporters, nitrogen metabolism and management, the molecular genetics of crop nitrogen use efficiency, genetic improvement of nutrient use efficiency.

Physiology of inorganic nutrients assembly: Hard & soft acids/bases, assemblers, physiology of assembly of metal ions with biomolecules, biological Lewis acids, amino acids-nucleic acid bases as metal assemblers, clusters, metalloenzymes.

The role of proton transport in nutrition: Energetics of nutrition, proton transport with or without charge compensation, proton motive force, proton pumps.

Potassium: Potassium levels in the vascular system and at the cellular level, potassium channel, the physiological role of the potassium ion (role in osmoregulation, cell expansion, regulation of stomatal opening & closing), potassium & hormones, accompanying anions.

Active oxygen: The oxidative problem, oxygen free radicals, the antioxidant system, the effect of nutrition on the plant's response to the oxidative problem, utility of glutathione.

Phosphorus: Properties of phosphate anion, role of phosphorus in photosynthesis, homeostatic mechanisms of phosphate metabolism, adenylate, pyrophosphate and its management, management and utility of phosphorylation, phosphorus mobility.

Magnesium: Magnesium levels, role of magnesium in stabilizing structures, magnesium in cellular compartments. Effect of magnesium on protein synthesis, photosynthesis, transcription, sugar level and ATPase. Magnesium deficiency and agricultural importance, competitive cations, magnesium & water deficiency, magnesium & reactive oxygen species.

Sulfur: Sulfur levels, uptake, transport, storage & reduction of sulphate, organic sulphur,

management of sulfur dioxide by the plant.
Iron: Iron levels, uptake strategies, iron transport & storage, phytoferritin, iron incorporation into structures & redox behavior, ferroproteins, iron & reactive oxygen species.
Calcium: Structural role of calcium in the cell wall. Calcium as a signal (calcium channel, calcium ATPase, calcium levels in subcellular spaces, calmodulin).
Zinc: Physiological roles, zinc-containing enzymes, zinc-activated enzymes, generation of reactive oxygen species.
Copper: Functions of copper, uptake, intercellular and intracellular transport and homeostasis of copper, trafficking of copper within the plant, prospects for optimizing copper use efficiency, the regulatory system of Cu/ZnSOD & FeSOD exchange.
Molybdenum: Molybdenum functions, molybdenum uptake, trafficking and homeostasis within the plant, the molybdenum cofactor, molybdenum-containing enzymes, analysis of nitrate reductase and nitrite reductase structures, connection with nitrogen and sulfur metabolism, prospects for optimizing molybdenum use efficiency.
Boron: Uptake and trafficking within the plant body, incorporation and physiological roles of boron, prospects for improving boron use efficiency.
Chlorine: Uptake, trafficking, homeostasis, functions of chlorine in the plant, prospects for optimizing chlorine use efficiency.
Manganese: Uptake, intercellular and intracellular transport and homeostasis, manganese assembly and functions, perspectives for optimizing manganese utilization efficiency.
Nickel: Nickel in plants, nickel functions, nickel uptake, transport and homeostasis, prospects for optimizing nickel use efficiency.
Toxic metals: Heavy metals, physiological basis of metal toxicity, metal-binding peptides, detoxification mechanisms.
<u>II. Nutrition physiology at crop level</u>
Crop root systems and soil nutrient uptake: Soil exploration, crop root system depth and distribution, major soil growth limitations, root system architecture, nutrient access and uptake, root response to localized nutrient stocks, plant and soil micro-organism interactions affecting nutrient availability, management to optimize uptake by the root system, fertilizer placement, rhizosphere engineering, endomycorrhizal fungi and plant nutrition.
The role of the rhizosphere in the efficiency of the use of nutrients by cultivated plants: The physicochemical properties of the rhizosphere, the structure of the soil in the rhizosphere, transport of nutrients in the rhizosphere, the availability of water in the rhizosphere, the redox potential of the rhizosphere, rhizosphere pH, carbon availability in the rhizosphere, nutrient use efficiency and availability in the rhizosphere as a result of root-microorganism interactions, nutrient uptake and root zone.
The relationship of nutrient use efficiency to foliar physiology: Radiation uptake and photosynthetic capacity per unit nutrient uptake, photosynthetic rate per unit nitrogen, increase in foliar photosynthesis through foliar architecture, modification of light extinction coefficient, optimization of the distribution of nitrogen in the foliage in relation to light absorptivity, reduction of respiration.
Senescence and nutrient cycling in cultivated plants: The senescence process, stay-green phenotypes, environmental modification of senescence, nutrient remobilization, regulation of senescence.
Drought and its effects on plant nutrition: Drought and global food production, interactions between water and ion flow in soil and roots, root growth under drought

conditions, individual nutrients and plant water relations.

Laboratory exercises
Exercises in a laboratory room with the aim of obtaining experimental data on the physiology of plant nutrition, interpreting them and presenting them in a laboratory report.
Exercises include:
1. The nutritional status of the leaf
2. Physiological parameters of the nutritional status of the leaf
3. Nutritional status and phenotype of the root system
4. Distribution of mycorrhizal fungi in a root system of a mycorrhizal plant

4. TEACHING METHODS--ASSESSMENT

MODES OF DELIVERY *Face-to-face, in-class lecturing, distance teaching and distance learning etc.*	Face-to-face In-class lecturing
USE OF INFORMATION AND COMMUNICATION TECHNOLOGY *Use of ICT in teaching, Laboratory Education, Communication with students*	• Learning process support through the course website • Collection of lab reports via email
COURSE DESIGN *Description of teaching techniques, practices and methods:* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, Internship, Art Workshop, Interactive teaching, Educational visits, projects, Essay writing, Artistic creativity, etc.* *The study hours for each learning activity as well as the hours of self-directed study are given following the principles of the ECTS.*	

Activity/ Method	Semester workload
Lectures	33
Skills Development	6
Laboratory practice	26
Writing Laboratory Report	26
Study	34
Total	125

STUDENT PERFORMANCE EVALUATION/ASSESSMENT METHODS *Detailed description of the evaluation procedures:* *Language of evaluation, assessment methods, formative or summative (conclusive), multiple choice tests, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral exam, presentation, laboratory work, other……etc.* *Specifically defined evaluation criteria are stated, as well as if and where they are accessible by the students.*	Oral final exam (100%) including: Open-ended judgment & documentation questions (the ability of the students to apply the principles and mechanisms and the way the subject is approached and documented by them)

5. SUGGESTED BIBLIOGRAPHY:

Hawkesford & Barraclough, The Nutrition of Crop Plants, 1st Greek edition, edited by D. Bouranis, Utopia Publishing, ISBN:978-618-80647-3-7

6. TEACHERS:

Lectures Styliani Chorianopoulou, Assistant Professor Dimitris Bouranis, Professor Laboratory exercises Styliani Chorianopoulou, Assistant Professor Dimitris Bouranis, Professor Emilia Eleni Nikolopoulou, Teaching assistant