**TRAINING PLAN OF THE KÁLMÁN KERPELY DOCTORAL SCHOOL OF CROP PRODUCTION AND HORTICULTURAL SCIENCES**

The Doctoral School examines the improvement of sustainable development and sustainable agriculture, precision farming and the related systems, methods and procedures, as well as development and innovation opportunities through the coordinated study of several interdisciplinary, complementary and mutually presupposing research areas of multiple fields of science.
The aim of the research programmes is to broaden agricultural research.

***Structure of the training programme***

In the scope of their training, students can take 3 different types of compulsory and non-compulsory courses.

1. *general courses* (compulsory): Agricultural research methodology, Sustainable land use, Crop models
2. *special courses* (compulsorily optional): Sustainable precision agriculture, Horticulture and environment, Soil cultivation systems, Soil protection and soil improvement, Soil and environment, Introduction to digital soil mapping, Integrated cereal production, The biological basis of plant production, Molecular plantbreeding, Dynamic plant physiology based on image analysis, Plant and environment, Soil fertility management, Environmentally friendly protection , Integrated pest management, Integrated approach of phytopathology, In vitro plant propagation and plant stress tolerance, Microbiology, Knowledge of precision farming machinery, Knowledge of precision farming machinery, Analysis of plant origin products, Plant production decision support models
3. Number of *announced* optional courses related to the topic: 33.

During the first four semesters of the doctoral training, the admission of three compulsory (6 credits) and two compulsory elective subjects (6 credits) is obligatory for the doctoral student. It is possible to complete 8 credits based on elective subjects. Completion of credits is confirmed by the lecturer of the subject based on the exam, dissertation, report, etc. required for the admitted subject.

During this period, a minimum of 4 x 30 credits may be collected from examinations, research, and educational activities. The last four semesters include 4 x 30 credits of research work. These are specific research and publication requirements that help doctoral students meet the publication requirements to initiate the process of acquiring the degree to a high standard.

The doctoral student can obtain the following credit values for the research activities carried out during the training period and their results (the credit value must be divided by the number of authors):

| **Publication category** | **Credit** |
|---|---|
| Journal articles in an international journal (peer-reviewed in a foreign language) | 30 |
| Journal articles in Hungarian foreign language journals (peer-reviewed in foreign language) | 30 |
| Journal articles in Hungarian Hungarian language journals (revised in Hungarian) | 25 |
| Journal articles in other international journals | 25 |
| Journal articles in other domestic foreign language journals | 20 |
| Journal articles in other Hungarian Hungarian language journals | 15 |
| Conference article (revised, international, foreign languages) | 15 |
| Conference article (revised, international, Hungarian) | 15 |
| Conference article (revised, in Hungarian, in Hungarian) | 15 |
| Conference article (other, international, foreign language) | 10 |
| Conference article (other, domestic, foreign language) | 10 |
| Conference article (other, in Hungarian, in Hungarian) | 10 |
| Educational publications in foreign languages | 10 |
| Dissemination publications in Hungarian | 5 |
| Participation in an international research program (team) | 5 |
| Participation in a domestic research program (team) | 5 |

| Code: | Name | Lecturer | Credit | 1. semester | 2. semester | 3. semester | 4. semester |
|---|---|---|---|---|---|---|---|
| **Obligatory** | | | | | | | |
| AT-KK-A5 | Agricultural research methodology | Dr. Csajbók József | 2 | X | | | |
| AT-KK-A10 | Sustainable land use I. | Dr. Nagy János | 1 | X | | | |
| AT-KK-A11 | Sustainable land use II. | Dr. Nagy János | 1 | | X | | |
| AT-KK-A3 | Crop models I. | Dr. Pepó Péter | 1 | | | X | |
| AT-KK-A4 | Crops models II. | Dr. Pepó Péter | 1 | | | | X |
| **Elective** | | | | | | | |
| AT-KK-B58 | Sustainable precision agriculture I. | Dr. Nagy János, Búvár Géza | 1 | X | | | |
| AT-KK-B59 | Sustainable precision agriculture II. | Dr. Nagy János, Búvár Géza | 2 | | X | | |
| AT-KK-B60 | Sustainable precision agriculture III. | Dr. Nagy János, Búvár Géza | 3 | | | X | |
| AT-KK-B1 | Horticulture and environment I. | Dr. Holb Imre | 1 | X | | | |
| AT-KK-B2 | Horticulture and environment II. | Dr. Holb Imre | 1 | | X | | |
| AT-KK-B3 | Horticulture and environment III. | Dr. Holb Imre | 1 | | | X | |
| AT-KK-B55 | Soil cultivation systems I. | Dr. Nagy János | 1 | X | | | |
| AT-KK-B56 | Soil cultivation systems III. | Dr. Nagy János | 1 | | X | | |
| AT-KK-B57 | Soil cultivation systems II. | Dr. Nagy János | 1 | | | X | |
| AT-KK-B7 | Soil protection and soil improvement I. | Dr. Blaskó Lajos | 1 | X | | | |
| AT-KK-B8 | Soil protection and soil improvement II. | Dr. Blaskó Lajos | 1 | | X | | |
| AT-KK-B9 | Soil protection and soil improvement III. | Dr. Blaskó Lajos | 1 | | | X | |
| AT-KK-B10 | Soil and environment I. | Dr. Kátai János | 1 | X | | | |
| AT-KK-B11 | Soil and environment II. | Dr. Kátai János | 1 | | X | | |
| AT-KK-B12 | Soil and environment III. | Dr. Kátai János | 1 | | | X | |
| AT-KK-B61 | Introduction to digital soil mapping I. | Dr. Pásztor László | 1 | X | | | |
| AT-KK-B62 | Introduction to digital soil mapping II. | Dr. Pásztor László | 1 | | X | | |
| AT-KK-B63 | Introduction to digital soil mapping III. | Dr. Pásztor László | 1 | | | X | |
| AT-KK-B13 | Integrated cereal production I. | Dr. Pepó Péter | 1 | X | | | |
| AT-KK-B14 | Integrated cereal production II. | Dr. Pepó Péter | 1 | | X | | |
| AT-KK-B15 | Integrated cereal production III. | Dr. Pepó Péter | 1 | | | X | |
| AT-KK-B19 | The biological basis of plant production I. | Dr. Marton Lajos Csaba | 1 | X | | | |
| AT-KK-B20 | The biological basis of plant production II. | Dr. Marton Lajos Csaba | 1 | | X | | |
| AT-KK-B21 | The biological basis of plant production III. | Dr. Marton Lajos Csaba | 1 | | | X | |
| AT-KK-B64 | Molecular plantbreeding I. | Dr. Pepó Pál | 1 | X | | | |
| AT-KK-B65 | Molecular plantbreeding II. | Dr. Pepó Pál | 1 | | X | | |
| AT-KK-B66 | Molecular plantbreeding III. | Dr. Pepó Pál | 1 | | | X | |
| AT-KK-B67 | Dynamic plant physiology based on image analysis I. | Dr. Szemán-Nagy Gábor | 1 | X | | | |
| AT-KK-B68 | Dynamic plant physiology based on image analysis II. | Dr. Szemán-Nagy Gábor | 1 | | X | | |
| AT-KK-B69 | Dynamic plant physiology based on image analysis III. | Dr. Szemán-Nagy Gábor | 1 | | | X | |
| AT-KK-B70 | Plant and environment I. | Dr. Kakuszi-Széles Adrienn | 1 | X | | | |
| AT-KK-B71 | Plant and environment II. | Dr. Kakuszi-Széles Adrienn | 1 | | X | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AT-KK-B72 | Plant and environment III. | Dr. Kakuszi-Széles Adrienn | 1 | | | X | |
| AT-KK-B25 | Soil fertility management I. | Balláné dr. Kovács Andrea | 1 | X | | | |
| AT-KK-B26 | Soil fertility management II. | Balláné dr. Kovács Andrea | 1 | | X | | |
| AT-KK-B27 | Soil fertility management III. | Balláné dr. Kovács Andrea | 1 | | | X | |
| AT-KK-B52 | Environmentally friendly protection I. | Dr. Holb Imre | 1 | X | | | |
| AT-KK-B53 | Environmentally friendly protection II. | Dr. Holb Imre | 1 | | X | | |
| AT-KK-B54 | Environmentally friendly protection III. | Dr. Holb Imre | 1 | | | X | |
| AT-KK-B79 | Integrated pest management I. | Dr. Radócz László | 1 | X | | | |
| AT-KK-B80 | Integrated pest management II. | Dr. Radócz László | 1 | | X | | |
| AT-KK-B81 | Integrated pest management III. | Dr. Radócz László | 1 | | | X | |
| AT-KK-B28 | Integrated approach of phytopathology I. | Dr. Kövics György | 1 | X | | | |
| AT-KK-B29 | Integrated approach of phytopathology II. | Dr. Kövics György | 1 | | X | | |
| AT-KK-B30 | Integrated approach of phytopathology III. | Dr. Kövics György | 1 | | | X | |
| AT-KK-B73 | In vitro plant propagation and plant stress tolerance I. | dr. Dobránszki Judit | 1 | X | | | |
| AT-KK-B74 | In vitro plant propagation and plant stress tolerance II. | dr. Dobránszki Judit | 1 | | X | | |
| AT-KK-B75 | In vitro plant propagation and plant stress tolerance III. | dr. Dobránszki Judit | 1 | | | X | |
| AT-KK-B40 | Microbiology I. | Dr. Karaffa Erzsébet Mónika | 1 | X | | | |
| AT-KK-B41 | Microbiology II. | Dr. Karaffa Erzsébet Mónika | 1 | | X | | |
| AT-KK-B42 | Microbiology III. | Dr. Karaffa Erzsébet Mónika | 1 | | | X | |
| AT-KK-B49 | Knowledge of precision farming machinery I. | Dr. Harsányi Endre | 1 | X | | | |
| AT-KK-B50 | Knowledge of precision farming machinery II. | Dr. Harsányi Endre | 1 | | X | | |
| AT-KK-B51 | Knowledge of precision farming machinery III. | Dr. Harsányi Endre | 1 | | | X | |
| AT-KK-B46 | Analysis of plant origin products I. | Dr. Kovács Béla Róbert | 1 | X | | | |
| AT-KK-B47 | Analysis of plant origin products II. | Dr. Kovács Béla Róbert | 1 | | X | | |
| AT-KK-B48 | Analysis of plant origin productsIII. | Dr. Kovács Béla Róbert | 1 | | | X | |
| AT-KK-B76 | Plant production decision support models I. | Dr. Nyéki Anikó | 1 | X | | | |
| AT-KK-B77 | Plant production decision support models II. | Dr. Nyéki Anikó | 1 | | X | | |
| AT-KK-B78 | Plant production decision support models III. | Dr. Nyéki Anikó | 1 | | | X | |
| **Optional** | | | | | | | |
| AT-KK-C1 | Organic crop production | Dr. Szabó András | 2 | Current semester of subject registration | | | |
| AT-KK-C6 | Fodder crops integrated production | Dr. Sárvári Mihály | 2 | | | | |
| AT-KK-C3 | Integrated herb production | Dr. Kutasy Erika | 2 | | | | |
| AT-KK-C12 | Integrated crop production | dr. Dóka Lajos Fülöp | 2 | | | | |
| AT-KK-C13 | Crop production on sandy soils | dr. Zsombik László | 2 | | | | |
| AT-KK-C67 | Integrated soiluse | Dr. Nagy János | 2 | | | | |
| AT-KK-C23 | Biological processes in the soil | Dr. Kátai János | 2 | | | | |
| AT-KK-C25 | Ecophysiology | dr. Veres Szilvia | 2 | | | | |
| AT-KK-C11 | Advanced water treatment technologies | Dr. Kovács Elza | 2 | | | | |

| | | | | |
|---|---|---|---|---|
| **AT-KK-C8** | **Water management of field crops** | **Dr. Csajbók József** | **2** | |
| **AT-KK-C20** | **Lysimetry** | **Dr. Zsembeli József** | **2** | |
| **AT-KK-C22** | **Agrochemical aspects of plant quality** | **dr. Vágó Imre** | **2** | |
| **AT-KK-C59** | **Soil physics fundamentals of land use** | **Dr. Rátonyi Tamás** | **2** | |
| **AT-KK-C68** | **Agricultural meteorology, climate contitions of the plant stock** | **Dr. Gombos Béla** | **2** | |
| **AT-KK-C28** | **Bio-energetics** | **Dr. Sinóros Szabó Botond** | **2** | |
| **AT-KK-C26** | **Environment friendly mechanisation** | **Dr. Harsányi Endre** | **2** | |
| **AT-KK-C27** | **Machines of plant protection** | **Dr. Hagymássy Zoltán** | **2** | |
| **AT-KK-C29** | **Machines of food industry** | **Dr. Vántus András** | **2** | |
| **AT-KK-C69** | **Element specification methods in agriculture** | **Dr. Kovács Béla Róbert** | **2** | |
| **AT-KK-C36** | **Plant metabolic products and their cytological analysis** | **Dr. Lisztes-Szabó Zsuzsanna** | **2** | |
| **AT-KK-C40** | **Viticulture technology** | **Dr. Bihari Zoltán** | **2** | |
| **AT-KK-C31** | **Fruit production** | **Dr. Gonda István** | **2** | |
| **AT-KK-C70** | **Bioactive components of fruit species** | **Gálné Dr. Remenyik Judit** | **2** | |
| **AT-KK-C71** | **Precision vegetable production** | **Takácsné Dr. Hájos Mária** | **2** | |
| **AT-KK-C34** | **Role of vegetables in human nutrition** | **Takácsné Dr. Hájos Mária** | **2** | |
| **AT-KK-C63** | **biological plant protection** | **Dr. Radócz László** | **2** | |
| **AT-KK-C53** | **Plant protection chemistry** | **Balláné dr. Kovács Andrea** | **2** | |
| **AT-KK-C56** | **weed biology, weed management** | **Dr. Radócz László** | **2** | |
| **AT-KK-C51** | **Insect physiological basics and their application in modern plant protection** | **Nagyné dr. Fónagy Adrienn** | **2** | |
| **AT-KK-C54** | **Toxicology** | **Dr. Prokisch József** | **2** | |
| **AT-KK-C57** | **Plant protection forecasting** | **Dr. Tarcali Gábor** | **2** | |
| **AT-KK-C55** | **Mycotoxins in agriculture** | **Dr. Pusztahelyi Tünde** | **2** | |
| **AT-KK-C72** | **Industrial wastes as possible plant nutrients** | **Dr. Tóth Brigitta** | **2** | |

## Description and requirements of the subjects of the Doctoral School

## OBLIGATORY SUBJECTS

**Agricultural research methodology** (Csajbók József PhD)

Characteristics and errors of human cognition. Methods of the cognition process. Concept and characteristics of primary research, secondary research, tertiary research. How can the results and validity of research be judged? Theoretical and practical issues of research topic selection. Ethical issues in research.

In vitro, in vivo experiments, field experiments. Design of crop production experiments (purpose of the experiment, factors, plots, treatments, replicates, accuracy of experimental results, influencing factors, homogeneity). Parts and characteristics of the experimental plan.

Estimation of treatment differences and experimental error. Real and internal repetitions. Determination of the number of repetitions required. Placement of plots. Possibilities of arranging one-factor experiments, randomization. Possibilities of setting up two-factor experiments. Possibilities of setting up three-factor experiments. Questionnaire surveys, question types. Elaboration of practical examples, statistical evaluation.

**Sustainable land use** (Nagy János DSc,)
The task of the course is to provide land use knowledge, to form the attitude of students for the sake of efficient farming and land protection, for them to be able to achieve the efficient use of natural and social resources, to achieve the maximum income, to preserve the balance of the natural environment by planning and managing the applied method of land use.
Function of land use. Land use patterns, interactions between environmental and land protection. Methods of farming and land use. Relationships between soil fertility, protection and field use. The main consequences of anthropogenic loads, ecological tolerance-based land use. Utilization of organic materials, organic fertilization. Land use planning. Utilization of disadvantaged soils. Land use analysis. Methods for studying the effects. Impact of land use on soil condition, effectiveness of production interventions, soil protection, balance of physical-biological environment and production efficiency. Choice of land use methods. Land use concepts. Land use systems and models. Reconciling natural features and land use.

**Crop models** (Pepó Péter DSc)
I. In the framework of the course, PhD students get acquainted with the ecological, biological and agrotechnical conditions of field crop production, as well as their interactive effects. Scientific presentation of plant physiological, plant ecological and agrotechnical conditions of field crop production. Agronomic bases, structure, operating mechanisms of crop production models. Crop production models of cereals. Scientific foundation for the cultivation technology of cereals, maize and other cereals. Crop production models of legumes and oilseeds. Scientific substantiation of cultivation technology of peas, soybeans and other legumes as well as sunflowers, rape and other oilseeds.
II. In the framework of the course, PhD students get acquainted with the ecological, biological and agrotechnical conditions of field crop production, as well as their interactive effects. Scientific presentation of plant physiological, plant ecological and agrotechnical conditions of field crop production. Agronomic bases, structure, operating mechanisms of crop production models. Plant production models of root and tuber plants, fodder plants. Scientific substantiation of the cultivation technology of sugar beet, potato and other root-tuber plants, as well as fibrous and other fodder plants.

## COMPULSORILY ELECTIVE SUBJECTS

**Sustainable precision agriculture** *(Nagy János DSc – Buvár Géza)*
The course provides comprehensive knowledge of the need for precision agriculture, the current situation and expected directions. Students will acquire the latest theoretical and practical knowledge in the application of precision and site-specific technologies. We present the latest modern technologies, various row guidance and automatic steering systems, site-specific and chlorophyll content-based nutrient supply. The course introduces precision field and horticultural crop protection, precision sowing and introduces fleet management systems.

**Horticulture and environment** *(Holb Imre DSc)*
In the scope of the subject we review the international and domestic situation of the cultivation of horticultural plants (fruit, grapes, vegetables, ornamental plants, herbs), the impact of environmental factors and the possibilities of influencing them. We deal with the following topics in detail: Origin and environmental needs of horticultural plants, ecological characteristics of major horticultural countries of the world, ecological characteristics of Hungarian horticultural production areas, environmental factors influencing the growth, production and quality of horticultural plants: weather, soil, topography, built environment: resistance and protection against harmful environmental factors: frost, ice, drought, wind, rain, high groundwater, soil salinity, strong solar radiation, cultivation equipment, the impact of climate change on the cultivation of horticultural crops.

**Soil cultivation systems** *(Nagy János DSc)*

The task of cultivation science is to enable the following by synthesizing the base subjects and their own knowledge: the recognition of natural constraints and their regularities that can be influenced by the elements of farming, which hinder the effectiveness of crop production in different production areas; establishing the necessity and possibilities of the application of certain cultivation technology methods, elaboration of its variants; assessment of the impact, duration and expected results of the planned cultivation technology in a soil-plant system.
The lecture of the subject aims to transfer a knowledge material in which, in addition to satisfying the needs of cultivated plants for the place of production, it explores the phytosanitary and product quality consequences of the shortcomings of cultivation technology (e.g. nutrient supply, irrigation, weed control, crop rotation, etc.).
Cultivation science, which is the science of the planned increase and protection of soil fertility, includes the following elements of crop production technology:
- tillage (knowledge of the factors determining the quality of cultivation and the applicability of its methods, as well as the tillage systems of cultivated plants);
- soil protection (theoretical foundations and technologies for the applicability of methods to prevent and eliminate physical, chemical and biological degradation of soils, e.g. erosion, deflation);
- soil improvement (theoretical foundations and technologies for the improvement of soils with unfavourable chemical and physical properties, e.g. acidic, saline and hydromorphic, etc.);
- fertilization (correlations determining the need, extent and method of nutrient supply to plants and application technologies of organic and inorganic fertilizers);
- weed control (interactions between field and weeds, production site and lifestyle systems, cultivation methods of weed control, in particular mechanical and biological interventions);
- irrigation (production site and cultivation technology-related consequences of irrigation efficiency, especially with regard to tillage, plant care, nutrient replenishment systems);
- crop rotation (theoretical foundations of crop rotation and main aspects and requirements of its application, with special regard to the requirements of sustainable crop production and dry farming);
- farming systems (major stages in the development of farming, in particular crop rotation and free farming systems).

**Soil protection and soil improvement** *(Blaskó Lajos DSc)*
Within the framework of the subject, students get acquainted with the role of soil in the environment, as well as the effects that lead to soil degradation. They deal with the classic tasks of soil protection, the pedological effects of erosion and methods of protection against it, the improvement of sandy and saline soils, the phenomena of physical soil degradation and how to prevent them, biological soil degradation and prevention possibilities. The subject devotes considerable space to the discussion of the effects of contaminants on soils, the formation and sources of soil contamination, and remediation methods aimed at cleaning soils contaminated to varying degrees and with different substances. It deals with the methods of damage assessment and risk analysis, and describes some successfully applied technologies of remediation on domestic soils through case studies. In addition, students will receive a wide range of information on the possibilities of improving soils with unfavourable colloidal content, the improvement of acidic, saline and saline soils, and the possibilities of preventing secondary salinization.

**Soil and environment** *(Kátai János CSc)*
Soil is the basis of crop production. Within the framework of the course, students review the conditions and circumstances of soil formation. Of the solid soil elements, not only the mineral but also the organic constituents play a key role. The quantity and quality of humus is important in establishing and maintaining soil fertility. Our aim is that students understand the relationships between the physical, chemical, and biological properties of soils at the level of ongoing processes. Among the physical properties and processes, the main topics are the problems of soil structure and water, heat and air management. Among soil chemistry, we consider the topic of soil colloids and soil acidity to be very important. We also emphasize soil microbiological processes related to nutrient management.
The soils of Hungary. During their previous studies, the students got acquainted with the genetic and soil geographical classification of Hungarian soils. The primary goal of the course is for students to know the processes and relationships that have developed, are formed, and our soils are still evolving today. In addition to the characteristics of the main soil types, the participants of the course also know the causal relationships of the dominant physical, chemical and biological processes in the soil. In recent decades, several soil classification systems have emerged (FAO, FAO / UNESCO, WRB). Our aim is to introduce these soil classification systems, with special regard to the WRB soil classification.
Soil as a renewable natural resource. Presentation of the state characteristics of our soils. The main principles of sustainable management in land use. Impact of natural ecological factors on soil fertility. Soil degradation processes. Preservation of soil fertility, possibilities of applying soil reclamation. Methods of nutrient replenishment and its effect on soil processes. The impact of human activity on improving soil quality. Soil pollution and remediation. Soil destruction, soil protection. Factors and forms of erosion, degrees of soil destruction. Soil aspects of erosion protection. Causes, forms and degrees of deflation. Pedological basics of defense. Soil protection information system. Soil protection strategies of the EU and Hungary.

**Introduction to digital soil mapping** (*Pásztor László, DSc*)
The students participating in the training will be introduced to the modern methods of soil data management and the modelling of their spatial problems. They get an overview of traditional and digital soil mapping, the use, applicability and displayability of the data collected during mapping. They get acquainted with spatial pedological databases and their applications in theory and practice. They gain knowledge about the most modern directions of spatial extension of soil features based on geostatistical, data mining and hybrid methods. They are introduced to the possibilities of estimating the accuracy and reliability of spatial predictions. Through concrete examples, they get acquainted with the most important elements and steps of spatial modeling.

**Integrated cereal production** *(Pepó Péter DSc)*
The course provides detailed, scientifically established knowledge for the complex, integrated development of cultivation technology for cereals, maize and other cereals. Interactive analysis of ecological conditions, biological-genetic bases and cultivation technological elements in cereals. Quantitative and qualitative grain models. Site and variety-specific grain models. Experimental-methodological issues for the further development of crop production technology.

**Molecular plantbreeding** *(Pepó Pál CSc)*
Plant biotechnology is an ever-expanding trend in education, research, development and production. According to scientific forecasts, the development of this discipline will accelerate more and more in the coming period and will put plant genetics, plant breeding, cultivation technology, plant protection and propagating material production on a new, more modern basis. Plant biotechnology includes the use of plant cells with new values and economic significance, cell and tissue culture, molecular and cell genetic methods that create plants, as well as the technological application of their products. By integrating conventional and biotechnological methods, the efficiency of plant breeding can be greatly increased.

**Dynamic plant physiology based on image analysis** *(Szemán-Nagy Gábor, PhD)*
Basics of photometry. History of microscopy. Basic properties of radio waves. The wave and corpuscular nature of light. Interactions of light and materials. Basics of geometric photometry. The simple microscope. Limits of the resolution of a light microscope. Magnification and empty magnification. The numerical aperture. Historical overview of microscopy. Safety rules, occupational safety. Safe handling of the microscope. Imaging of a complex microscope.
The formation of the image. Structure and parameters of the lens, tube and eyepiece. Image capture procedures. Lens defects and their correction. Handling of lenses. Mechanical construction and maintenance of basic microscope types. The stereomicroscope. Light sources in microscopy.
Significance of illumination. Characteristics of the light source. The effect of illumination wavelength on resolution is the Abbe equation. Characteristics of laser light sources. Filter properties. The mirror and the condenser. Special condensers. Köhler's illumination. Monochromatic, polarizing and laser illumination. Methods of illumination.
Dark field of view lighting. Incident light. Phase contrast procedure. Differential interference contrast microscopy. The polarizing microscope. Spatial polarization microscopy. Stereomicroscopy. Fundamentals of confocal microscopy. Fluorescence microscopy.
Fluorescence as an imaging phenomenon. Structure of fluorescent microscopes. The practice of fluorescence microscopy. Basics of electron microscopy.
Transmission electron microscopy. Scanning electron microscopy. Characteristics of electron microscopic samples. Evaluation of electron microscopic images. Three-dimensional reproduction of microscopic structures.
Significance of the focal plane. Use of structured light in microscopy. The basics of digital imaging. Pixel, voxel, volumetric and surface models. Spatiality as information in microscopy. Making layer shots. 3D rendering. Stereoscopic display. Basics of computer image processing. Chromatin Image Analyzer 3.0 software. Image processing using real-time shared resources. The DRIP system. Basics of bioinformatics.
Analog to digital conversion. Signal to noise ratio. Structural features of biological information. A/D devices in computers. Sampling frequency. Conversion resolution. Digital processing of biological signals. Biological databases. Publication databases. Specific search. Scientific ethics on the Internet.

**Plant and environment** *(Széles Adrienn PhD)*
Understanding the interactions between the plant and its environment, studying life processes and regularities, and monitoring how the plant responds to changed environmental conditions are of key importance. To do this, it is necessary to know the environmental parameters of the

given production site, the stress effects resulting from the sudden change of the environmental parameters and what changes they induce in each plant species.
Main topics: study of plant habitat (soil; light and climatic conditions). The mineral balance (soil as a source of nutrients; uptake of plant minerals, utilization of minerals, incorporation into plants; issues of nitrogen home use: effect of NO3- and NH4 + nutrition on metabolism; site-specific characteristics of mineral nutrition). Water balance of the plant. Plant development and the environment. Plants and stress (light stress, temperature stress, drought stress).

**The biological basis of plant production** *(Marton L. Csaba DSc)*
The role of crop production factors in the formation of the average yield. Significance, concept, objectives and steps of plant breeding. The extent of the genetic contribution to the growth of yield averages. The impact of crop production technology and climate change on plant breeding objectives. Plant breeding and the evolution of cultivated plant species. Domestic and international history of plant breeding, its main domestic institutions
Outstanding personalities and institutions in the history of plant breeding. Raw materials for plant breeding. The task, significance and forms of gene conservation (gene banks). Breeding methods. The role of variation in plant breeding. Environmental and genetic variations. Qualitative and quantitative variations. Sources of variability, crossing, mutation, polyploidy, biotechnology. The concept and theory of selection. Principle and methods of breeding self-fertilizing plant species. Methods of breeding alienated plant species. Mass selection, individual selection, recurrent selection. Heterosis breeding. Production of hybrid and synthetic varieties. Methods for the production of inbred strains. Judging the value of inbred strains per se and in combinations. Biotechnological methods in plant breeding.

**Soil fertility management** *(Balláné Kovács Andrea DSc)*
Aim: to present the agrochemical basis of environmentally friendly nutrient replenishment: the effect of fertilization on the quantity, quality and environment of the crop; principles of sustainable and environmentally friendly nutrient management; potential harmful effects of fertilization; the role of soil properties (pH, redox potential, binding) in the circulation of essential and toxic elements. The relationship between nutrient supply and water management; the role and uptake of individual nutrients, deficiency symptoms; properties of soil as a natural source of nutrients, fertilizers, organic fertilizers, their application; soil testing methods and possibilities that form the basis of fertilization expert advice; basic principles of fertilization consulting. The MÉM-NAK method, the economical and environmentally friendly method of MTA-TAKI.

**Integrated approach of phytopathology** *(Kövics György CSc)*
*I. Pathology and Diagnostics*: Introduction: Healthy and Diseased Plants - Trends in the Human Population - Food Demand - Consumer vs. poor societies - losses in the chain of crop production, storage, transport, use.
Chapters in the history of plant pathology: from antiquity to the present day - recognition of the role of pathogenic fungi - history of phytobacteriology - history of plant virology - history of disease control - history of Hungarian plant pathology.
Etiology (pathology), pathogens (proportions, genetic, climatic, edaphic and environmental causes, etiology of infectious plant diseases.
Phytopathogenic bacteria and phytoplasmas.
Plant viruses, virus-like agents (viroids, satellite RNA, DNA, satellite viruses, VLPs, interfering defective particles, etc.).
Diagnosis of the causes of plant diseases: difficulties - visual diagnostics (symptomatology) - microscopic examinations - tools and methods of laboratory examinations - electron microscopy.
Modern possibilities of diagnosis: serology-based diagnosis (ELISA types); protein and nucleic acid based diagnosis (isozyme, PCR, etc.).

*II. Mycology:* General knowledge of mycology. "One name - one fungus" vs. the fungus is holomorphic (anamorphic and teleomorphic).
Phytopathogenic false fungi (Protozoa, Chromosomes) and real fungi (Fungi); Zygomycota, Chytridiomycota; Ecto- and endomycorrhizae, orchid and ericoid mycorrhizae, endophyton fungi; Ascomycota; Basidiomycota; Mitospore fungi; Mycotoxins (phyto- and zootoxins).
*III. Pathogenesis, pathophysiology, epidemiology, prognosis, defense:* pathology (pathogenesis). Parasitism and pathogenicity, host plant range, stages of the pathology cycle in the plant (inoculation - penetration - infection - dissemination - inoculum formation - unfavourable period survival).
Pathophysiology: the effects of pathogenesis on the physiological functions of the plant (changes in photosynthesis - water and nutrient transport, water absorption of roots, transport in the xylem, evaporation). Changes in respiration, cell permeability, transcription, and translation. Effects on plant hormones, growth, reproduction. Genetics of plant diseases (diseases and genes, variability of pathogens, mechanisms). Types of disease resistance (horizontal resistance, R-gene resistance, monogenic or vertical resistance. Disease resistance (resistance) and tolerance. Pathogen virulence and host plant resistance (pathogenicity genes in pathogens (fungi, bacteria, viruses), pathogen. Signaling system between pathogenicity genes and resistance genes, Programmed Cell Death (PCD), SAR.
Epidemiology (epidemiological conditions, mono- and polycyclic diseases, phenology-independent, juvenile and senescent plant-preferred diseases) Prognosis: possibilities for predicting plant diseases.
Integrated protection against plant pathogens. Agrotechnical, mechanical, physical, chemical, biological, pest monitoring control.

**Integrated pest management** *(Radócz László CSc)*
The purpose of agricultural production and plant protection. Economic regulation. The concept of pest, the evolution of pests. A critical review of non-biological control methods and unilateral production-centric farming. The economic paradox of chemical control. Laws and contexts defining plant protection: Malthus law, Verhulst-Pearl law, Lotka-Voleterra equations, Volterra rule, Allee rule, evolving and mature systems, operation of systems (entropy in ecology, network law, Donella Meadows 12 points), the Kuznets curve, the environmental Kuznets curve. The effects, side effects and side effects of conventional farming and plant protection.
Methods of defense. Historical overview (evolution of defenses). Ethics of plant protection. Agrotechnical, mechanical control. Chemical control (mechanism of action of insecticides, EU regulations). Biological control (biotechnological control, transgenic plants). Environmental regulation. Relationship between biological plant protection and integrated pest management. Historical background. Requirements for integrated pest management in the European Union. Calculation and applicability of the economic threshold. Integrated Pest Management in the EU and Hungary.

**Environmentally friendly protection** *(Holb Imre DSc)*
History, domestic and international situation of environmentally friendly (integrated and ecological) horticultural (fruit, vegetable, ornamental) plant protection. Legal regulation of organic and integrated farming. Biology of pathogens and pests of cultivated horticultural species The nature of the damage caused and the peculiarities of natural enemies: deviations from integrated cultivation. Elements of the technology of organic cultivation, identities and differences with integrated cultivation: use of varieties and propagating material, choice of place of production, preparation of area, choice of propagating material, care operations, irrigation, tillage, harvesting, storage. Enforcing the ecological approach in plant protection. Providing detailed theoretical and practical plant protection technology knowledge on major fruit, vegetable and ornamental plant species. Plant protection aspects of biotechnology in horticulture.

***In vitro plant propagation and plant stress tolerance*** *(Dobránszki Judit CSc)*

*In vitro propagation of soft and woody plants.* In vitro propagation of fruit plants (eg apples, plums, cherries), forestry (eg acacia, walnut) and energy-growing (eg willow, emperor) woody plants, as well as herbaceous horticultural plants (eg potatoes) research. Investigation of the effect of in vitro factors influencing axillary and adventive shoot multiplication, development of new methods to increase the efficiency of in vitro propagation. Investigation of the effect of various in vitro factors on the physiological and quality parameters of developing shoots and plants. Development and investigation of acclimatization methods, study of their physiological and qualitative effects. Development of new in vitro technologies or their individual elements.
*In vitro study of osmotic stress tolerance.* Development and adaptation of in vitro methods for testing the resistance / tolerance value of abiotic (mainly osmotic: water and salt stress) stresses in different vegetable, fruit and field plant species (eg potatoes, peas, apples). Determination of the in vitro abiotic stress tolerance value of different species, lines and clones of each species, investigation of the correlation with the in vivo (greenhouse and field) abiotic stress tolerance. The topic mainly includes basic methodological research and the study of morphophysiological and biochemical parameters and their applicability as markers.

**Microbiology** *(Karaffa Erzsébet Mónika PhD)*
The aim of teaching the subject is to provide up-to-date knowledge that allows the student to describe special chapters and environmental aspects of microbiological knowledge of outstanding agricultural importance, using the latest, up-to-date scientific knowledge.
The main topics of the subject are: Diversity of bacteria. Diversity of mushrooms. Diversity of viruses. Ecology of microorganisms (humidity, temperature, pH, pressure, radiation, salinity). The role and significance of microorganisms in biogeochemical processes. Microbial ecosystems. Microbial ecological test methods. Microbial symbioses. Genetic engineering and biotechnology. Major metabolites of microorganisms. Microbiology of fermentations. Pathogenicity and infection. Foodborne illness (foodborne infections, food poisoning). Microbiology and spoilage of various products and foods.

**Analysis of plant origin products I.** *(Kovács Béla PhD)*

The primary objective of the course is to acquaint PhD students with the most important analytical and mainly instrumental analytical measurement methods needed to determine the quality and composition of plant raw materials and products.
The most important knowledge in the first semester is the following:
Basic concepts in analytical chemistry. Basic physical measurements in analytical chemistry. Units of measurement. Discussion of mass, volume, pressure, temperature, density, viscosity, melting point, boiling point, flash point, conductivity, and pH. The process of analysis, the process of multi-element chemical analysis. Form of presentation of analytical results and their errors, accuracy of results, basic statistical concepts and validation of measurement methods. Calibration, standard addition, internal standard method, spiking.
Description of classical analytical measurement methods.

Analysis of plant origin products II.

The primary objective of the second semester is to acquaint PhD students with the most important analytical and, in particular, modern instrumental analytical measurement methods needed to determine the composition of plant raw materials and products. Accordingly, the most important knowledge in the semester is the following:
UV/VIS photometry. Flame emission spectroscopy (FES). Flame atomic absorption spectroscopy (FAAS). Graphite furnace atomic absorption spectroscopy (GF-AAS). Inductively coupled plasma optical emission spectrometry (ICP-OES). Inductively coupled plasma mass spectrometry (ICP-MS).

During the semester, we deal with the principle of the above instrumental analytical measurement methods, detailing the information needed to measure quality and quantity, with the most important structure of the devices, with the detailing of the measurement errors arising from the measurement of the measurement techniques, as well as with their elimination or at least reduction, as well as with the possibilities of applying the measurement methods, bearing in mind that the above measurement methods are intended to be used for special testing of plant raw materials and products. Accordingly, during the detailed discussion, the measurement methods are described through the presentation of qualitative and quantitative sample analyses of plant samples.
Comparison, evaluation and applicability of the individual measurement methods.

Analysis of plant origin products III.
In the scope of the lectures, the methods developed for the determination of the main components of plant raw materials and products will be discussed. The lectures first deal with the development of chromatographic methods and their significance in the analysis of plants, followed by their grouping according to the mechanism of separation, the shape of the stationary phase and the state of the mobile phase.
This is followed by a discussion of liquid chromatography, its purpose, and then a description of liquid chromatography methods. Presentation of the parts of the liquid chromatograph and the fields of application of normal phase and reverse phase chromatography, as well as stationary and mobile phases, and finally liquid chromatography.
We then proceed with the other important field of chromatography, gas chromatography, its principle and purpose, and then the description of gas chromatography methods. The basics of adsorption and partition gas chromatography follow, as well as the parts of the gas chromatograph, the description of various columns and packings, the significance of the capillary column, and finally the fields of application of gas chromatography.
Finally, the importance and structure of the various types of mass spectrometers widely used in chromatography and the operation of the quadrupole mass analyzer are described.
The lectures also include the definition of nitrogenous substances; within this, the student can get acquainted with the determination of the protein content, the protein fractions and the amino acid composition of the protein. After determining the fat content and fatty acid composition, the crude fiber and crude fiber fractions are examined. In the line of nitrogen-free extractables, the lectures also deal with the determination of sugars and starch.

**Knowledge of precision farming machinery (Harsányi Endre, PhD)**
Thinking according to age, a farmer should set himself three goals. One is to produce high yields when produced to a high standard. The other is to keep costs in check. The third is to meet sustainability expectations.
Precision farming can meet these objectives. This means that one intervention can sometimes satisfy conflicting goals. Precision farming has some characteristics that are significantly different from the previous ones, we could say that from centuries-old, possibly millennial agricultural fixations. One of them is that it builds agrotechnical interventions in the process and management of production on objective measurements and observations. The other characteristic is that based on these objective measurements, he wants and is able to intervene in the production process. The third is that objective observations and measurements are of high density, so that a map and action plan can be created within the board. It follows that if the objective measurements show heterogeneity within the table, the heterogeneity will appear as a map, and a heterogeneous answer can be given. Previously, the table was averaged based on the observations and this provided the basis for the task definition. Of course, the experience of the previous period, the production experience of oneself and others, as well as the results of the experiments are still used in production today, because only on this basis can production be planned and started.
Precision farming is highly connected to technical, technological scientific results and the material realizations of scientific results. Such are positioning systems and the closely related

automatic steering. Such is the use of highly diversified sensing and the closely related data acquisition and transmission technologies.
Thinking according to age, a farmer should set himself three goals. One is to produce high yields when produced to a high standard. The other is to keep costs in check. The third is to meet sustainability expectations.

**Plant production decision support models (Nyéki Anikó, PhD)**

The subject matter includes the presentation of the structure and data requirements of plant growth models; the importance of their application in the process of scientific knowledge. The direct goal of simulation crop production models is to describe the processes of a complex soil-plant-atmosphere system with mathematical tools and to simulate them using a computer. The main advantage of simulation models is that they are suitable for the approximate description of the processes taking place within a complex system and the interactions between complex systems. The models provide an opportunity to chronologically track biomass, grain weight, leaf area, leaf number, and phenophases under given soil, nutrient supply, and climatic conditions.
The main aim of the course is to present these models, their databases and their applicability, including the technology system of sustainability and precision crop production.

**OPTIONAL SUBJECTS**

**Organic crop production** *(Szabó András PhD)*
A holistic system of crop production by comparing traditional, integrated and ecological models. Socio-sociological contexts of organic crop production. The role of sustainability in organic crop production. A three-dimensional quality model of crop production. Scientifically based evaluation of agrotechnical elements used in organic crop production. Investigation of the interactive effects of biological bases and ecological conditions in organic crop production.

**Fodder crops integrated production** *(Sárvári Mihály CSc)*
In the future, not only quality food production will be extremely important, but the development of the cultivation technology of fodder plants with the right content (soybeans, peas, alfalfa, corn, etc.), appropriate management, development, increase of crop safety, creative research in the scope of domestic PhD training might provide solutions. The development and rationalization of the cultivation technology of protein-rich plants in human nutrition and animal feed is extremely important, and the solution awaits the scientists of the future, researchers with PhD degrees. In the future, the development of technology for growing alternative fodder crops will need to be intensified, necessitated by weather extremes due to climate change. Among the alternative fodder crops, the task will be the regional and technological development of fodder circuses, corn ledges, phacelia and vetch.

**Water management of field crops** (*Csajbók József PhD)*
The effect of abiotic and biotic stress factors on the water management of field crops and the efficiency of water consumption. The relationship between permanent and temporary water abundance and the environment. The relationship between water supply and erosion. Effects of water scarcity on field crop production. The relationship between the elements of cultivation technology (crop rotation, nutrient supply, tillage, sowing technology, plant protection, irrigation) and water management of plants. Relationships between water supply and environmental quality. Relationships between water supply and product quality.

**Advanced water treatment technologies** *(Kovács Elza PhD)*

Educational objective of the course: Students get acquainted with the most modern drinking water treatment technologies and solutions for the targeted pre-treatment of water intended for agricultural and other industrial use, as well as understands the causal connections of water treatment and use. They also learn about communal and some industrial wastewater treatment technologies and understand the relationship between technological interventions and surface water quality protection. They will be able to independently evaluate real cases related to water treatment and analyse alternatives.

**Integrated crop production** *(Dóka Lajos Fülöp PhD)*
The purpose and role of crop production in the national economy. The situation of crop production in the world, in the EU, in Hungary. Goals, tasks, problems, development trends. Characteristics of multifunctional crop production. Concept, elements, models of integrated crop production. Elements and characteristics of sustainable crop production. Alternative crop production systems, new directions, impact on the environment. Agroecological, biological-genetic and agrotechnical conditions and factors of crop production. Crop production and environmental protection. Characteristics of GMO crop cultivation, advantages, disadvantages, impact on the environment, health, latest research results. Material and energy processes in crop production. "Green" energy industry, energy production in crop production. Quality dimensions in crop production. Production of food, feed, industrial raw materials in crop production. Organic crop production. Parallel farming.

**Crop production on sandy soils** *(Zsombik László PhD)*
The aim of the course is to acquaint students with the knowledge of crop production related to sandy soil farming. The subject includes all activities that are an integral part of crop production, but specially adapted to sandy soils. The student can also get acquainted with the tillage procedures of sandy areas and the peculiarities of nutrient supply. In order to study and reduce soil degradation processes, knowledge can be gained from long-term experimental data. The subject also introduces the cultivation technologies of alternative plants that can be grown only on sandy soils.

**Agricultural meteorology, climate contitions of the plant stock** *(Gombos Béla PhD)*

Meteorological conditions basically determine the living circumstances of the plant, the efficiency of cultivation. Today, weather is one of the biggest uncertainties in crop production, which has persisted with significant advances in agrotechnics (e.g., precision crop production). With agrometeorological knowledge and information, it is possible to minimize weather damage and make high use of climatic conditions. It should be emphasized that the tools of agrometeorology can often be used indirectly - in interaction with other ecological factors or with an agrotechnical element. Essentially, the knowledge of agrometeorological factors can be expected and taken into account in all crop production disciplines. Adding to the importance of the subject is the fact that climate change is facing new challenges in agricultural practice that require agrometeorological research.
The aim of the course is to acquaint PhD students with the agrometeorological contexts that serve the objectives presented above and to be able to link them to the knowledge of their own agricultural field and to apply them effectively in their PhD research and later in their professional careers.
The course provides students with the general and specific agrometeorological knowledge required for a wide range of crop production research, assuming basic meteorological knowledge.
The course provides students with the general and specific agrometeorological knowledge required for a wide range of crop production research, assuming basic meteorological knowledge.

The main topics of the subject: The climate of Hungary. Climatic characteristics of air temperature, humidity, solar radiation, and wind and precipitation conditions with the presentation of multi-year averages, extreme values, annual course, and spatial differences.
Meteorological/agrometeorological measurements, measuring instruments, with special regard to the sources of error and representativeness of the measurements.
Microclimate. Radiation energy balance, air movement in soil space, microclimatic characteristics of temperature and humidity, microclimate of plant stocks, topography, surface cover and the effect of soil characteristics on the microclimate, stock climate of arable crops and horticultural crops.
The effect of temperature on plants. Temperature cardinal points, the relationship between phenological development and meteorological factors, heat sum methods.
Agrometeorology of agricultural water management. Water demand, water consumption, water supply, drought, drought indices, hydrometeorological bases of irrigation, evaporation calculation methods, irrigation management systems.
Agrometeorological models. Yield estimation models and their types: analysis models, statistical models, simulation plant-soil-weather models. Plant protection models. Methods of agrometeorological research. Agrometeorological information and their utilization.
Compulsory literature: Szász G.- Tőkei L. (1997): Agrometeorológia mezőgazdáknak, kertészeknek, erdészeknek (Agrometeorology for farmers, gardeners, foresters). Mezőgazda Kiadó. Budapest. Suggested literature: Barry, R.G – Blanken, P.D. (2016): Microclimate and Local Climate. Cambridge University Press.

**Soil physics fundamentals of land use** *(Rátonyi Tamás PhD)*
The primary goal of the teaching of the subject is to provide knowledge on land use that complements the core material of general education, to form the attitude of the students. Students should be able to realize the efficient use of the natural and social resources given to cultivation, to achieve the maximum income, to preserve the balance of the natural environment by planning and managing the way of land use.
The concept and function of land use. Land use patterns, interactions between environment and soil protection.
Method of cultivation and land use. Relationships between soil fertility, protection and field use. The main consequences of anthropogenic soil loads are land use that takes into account the ecological tolerance. Utilization of organic materials, organic fertilization. Land use planning. Utilization of disadvantaged soils. Analysis of impacts from land use. Methods for studying the effects. Impact of land use: on the yield and quality of individual crops, soil condition, effectiveness of production interventions, soil protection, balance of the physical-biological environment, production efficiency. Choice of land use methods. Land use concepts. Land use models. Reconciling natural conditions and land use.

**Integrated soiluse** *(Nagy János DSc)*

The primary goal of the teaching of the subject is to provide knowledge on land use that complements the core material of general education, to form the attitude of the students. Students should be able to implement the natural and natural conditions of cultivation by planning and managing the way of land use. efficient use of social resources, achieving maximum income, preserving the balance of the natural environment.
The concept and function of land use. Land use patterns, interactions between environment and soil protection.
Method of cultivation and land use. Relationships between soil fertility, protection and field use. The main consequences of anthropogenic soil loads are ecological. land use taking into account tolerance. Utilization of organic materials, organic fertilization. Land use planning. Utilization of disadvantaged soils. Analysis of impacts from land use. Methods for studying the effects. Impact of land use: on the yield and quality of individual crops, soil condition, effectiveness of production interventions, soil protection, balance of the physical-biological

environment, production efficiency. Choice of land use methods. Land use concepts. Land use models. Reconciling natural conditions and land use

**Lysimetry** *(Zsembeli József PhD)*
The concept and history of lysimetry. Types of lysimeters. Technical basics of lysimetry. Soil moisture circulation. Modelling the hydrological cycle. Determination of water balance elements with lysimeters. Soil moisture and temperature profile. Land use and climatic effects. Moisture-saving tillage. Lysimeters for moisture-saving tillage. Water supply and water demand of plants. Determining the efficiency of plant water use. Determination of soil salinity with lysimeters. The European Lysimeter Platform. Lysimeters in Europe.
After completing the course, the students will be able to assess the importance of regulating soil water management, they will know the types of lysimeters and their applications at the domestic and international level.
They get to know the role of irrigation and moisture-saving tillage in the regulation of soil water circulation, and acquire skills in their practical implementation.

**Agrochemical aspects of plant quality** *(Vágó Imre CSc)*
The aim of teaching the subject is to develop or strengthen an attitude in doctoral students that considers the quality of the goods produced to be at least as important as their quantity and economic nature. The effect of various agrotechnical factors, such as nutrient and water supply on plants, microbiological preparations, organic yield stimulants and chemical plant protection, on quality.
Subject topics: Chemical composition of plants, inorganic and organic matter content of plants. Plant nutrients and their classification. Nutrient uptake and factors influencing it (soil, climatic and biological parameters). Relationship between nutrient supply and yield. Impact of nutrient supply on the quality of individual plant products: cereals, root and tuberous plants, certain oilseeds, natural and planted grasslands, vegetables, fruits, industrial crops. Determining the nutrient requirements of plants. Impact of nitrogen deficiency and excess on product quality and the environment. Impact of inadequate phosphorus and potassium supply on quality. Calcium and magnesium deficiency and its consequences. Grass tetany. Sulphur deficiency and its symptoms and consequences. Iron deficiency and its symptoms, effect. Lack of essential microelements, their effect on the quality of plant products. Non-essential elements in food raw materials or plant products for animal feed. Effects, dangers. Effects of different pesticides on quality. Persistence, metabolites, waiting time for occupational and food health. LD50, LC50, EC50 concept, significance. Hazard categories. Local, locosystemic and systemic agents and their effect on product quality.

**Biological processes in the soil** *(Kátai János CSc)*
Soil is an important abiotic component of the biosphere, natural and artificial ecosystems. Students will learn about soil organisms, representatives of their major groups, and their role in the material cycle and energy flow. We emphasize soil biological processes and the importance of biodiversity. Soil, as an environmental factor, and its inhabitants interact closely, while living organisms also interact with each other. This system of relationships also includes the interactions of microorganisms and higher plants. Ecological and agrotechnical factors have a multifaceted impact on soil organisms and their activities. We present the role of soil organisms in sustainable farming.

**Ecophysiology** *(Veres Szilvia PhD)*
Discussion of the effects of biotic and abiotic factors that determine the qualitative and quantitative characteristics of plant production, which also determines the amount of plant-based food. Among the abiotic factors, the quality and quantity of light, including UV-B radiation at low and high temperatures, water scarcity and flooding, the physiological analysis of the effects of air composition in the light of plant-based product formation. Among biotic

factors, the explanation of the negative and positive effects of different organisms, especially the role of microorganisms that play an important role in alternative plant nutrition.

**Environment friendly mechanisation** *(Harsányi Endre PhD)*
Environmentally friendly tractor engines. Development of power machines. Running gear, wheel/ground connection. Driving dynamics, driving safety, driver comfort. Energy - saving tillage machines. Environmentally friendly mechanization of organic fertilization. Environmentally friendly mechanization of fertilization. Water-saving irrigation machines and equipment. Environmentally friendly plant care and plant protection machines. Forage harvesters. Energy-saving crop drying equipment. Agricultural buildings. Machines and equipment for environmentally friendly cattle, pigs and poultry. Technical issues of sustainable agriculture.

**Machines of plant protection** *(Hagymássy Zoltán PhD)*
Due to the use of chemicals, the professional adjustment of plant protection machines, the acquisition of application techniques and a deeper knowledge of equipment testing are of key importance in agricultural production. The course also provides an opportunity to review environmentally friendly plant protection equipment.
Main topics: Application technical issues of sprayers. Evaluation of spraying pattern. Elements of the flow system of sprayers. Pumps, drop creation, nozzles used on sprayers air-conveyed, air-pulverizing sprayers. Operation of sprayers. Environmentally friendly plant protection processes and equipment.

**Bio-energetics** *(Sinóros-Szabó Botond DSc)*
The course deals with the energy produced from biomass, its peculiarities, processes, connections, and the presentation of its long-term tendencies. It discusses all of these in two main groups of systems; on the one hand, it deals with the generation and production of biomass, and on the other hand, it describes the basic contexts of energy production, its technological variants, the hardware and software relations, and the defining characteristics of the generated energy product.
It deals with the domestic and European conditions of biomass production, and with its place and role in the world. It explores and presents direct relationships between the place of production, the variety, and the characteristics of the biomass product, and the energy conversion, energy products. It analyzes and synthesizes the mentioned relations, and presents the relationship and effects of all these in terms of the quantity, quality, efficiency, safety of energy production, and the profit that can be gained during commercial utilization.
The course systematizes the relations and defining characteristics of biomass and energy production (bioreactor, biodiesel and bioethanol plants, biomass heating plants), which covers the production site and the production of biomass, the production and utilization of the energy product and the use of biomass remaining after conversion. The main features of this system are also explored in the course, interpreting the material and energy processes, and the characteristics of these, as well as the logistics of the whole system, influencing and determining them.

**Machines of food industry** *(Vántus András PhD)*
Students will learn about the most important technological operations used in the food industry, their theoretical contexts, and the most typical machines suitable for performing each operation. They gain knowledge of the general structure and operating principle of machines. They become aware of the task, field of application and conditions of the given machine and equipment. Students should acquire knowledge of the machines and equipment of transport, be

informed about the machines suitable for the separation and homogenization of different materials and the machines for shredding. Students get to know the machines for cleaning, grading and sorting materials and products. Students should acquire knowledge of machines for pressing, passing, evaporating, and cooling raw materials and finished products.

**Fruit production** *(Gonda István CSc)*
Introduction of the ecological conditions, biological bases and intensive cultivation technologies for increasing the intensity of fruit species grown in Hungary (apples and stone fruits), creating the theoretical foundations of practical training.
In the scope of the subject, students get acquainted with the history of the development of the Hungarian cultivation systems. They are also introduced to the aspects of subject and variety selection. They gain detailed knowledge of site selection, site preparation, planting material selection, and the technical structural elements of plantations (support system and irrigation equipment). Crown-forming and maintenance pruning elements as well as other phytotechnical operations applicable in intensive orchards are taught. The material to be taught details the different care operations (tillage, nutrient management, irrigation, plant protection, mechanization). We also cover the details of the post harvest activity.

**Precision vegetable production** *(Takácsné Hájos Mária CSc)*
Site-specific farming is also becoming important in vegetable production, increasing the profitability of the sector. The practice of precision farming is closely linked to soil-friendly cultivation methods, which have a lower environmental impact.
Acquiring the basic knowledge (methodological and cultivation science basics) necessary for the formation of the optimal species (or variety type) structure for cultivation in addition to the existing system of conditions (climatic conditions, length of growing season, average temperature values and extremes, natural rainfall, etc.).
Compared to the application of previously known precision technologies, there is a difference here in the method of irrigation and yield mapping.
Emphasis will be placed on the application of linear, microspray and drip irrigation to provide a variable intensity water supply, depending on the species and the crop area.
This cultivation involves learning about the modern tools of mechanized harvesting, which are equipped with GPS and yield sensors, or the use of robotic tools.
The aim of the course is to demonstrate the economic efficiency of site-specific farming and soil-friendly cultivation using the appropriate technology that allows for increased yields and more favourable use of input material.

**Bioactive components of fruit species** *(Gálné Remenyik Judit PhD)*
The aim of the course is to present modern separation technical basics, which allows the student to determine the content parameters and bioactive components of cultivated vegetables and fruits by quantitative and qualitative analytical methods.
In addition to these, students master a protocol that allows the isolation of new types of chemical components.
Main topics of the subject: Fractionation of soluble and insoluble components. Properties of oligosaccharides, characterization of major oligosaccharides. Occurrence of simple sugars in plants, their definition. Methods of measuring proteins, their separation. Measurement of water- and fat-soluble vitamins. Measurement of energy balance. Macro- and microelements. Organic contaminants. Fatty acid profile or isoprene derivatives. Phenolic components, gallic acid derivatives.

The most important steps in the biosynthesis of a given compound. Characterization of its physical and chemical properties, based on which the suitable isolation technique can be chosen.
Getting to know the most significant instrumental analytical methods, their theoretical foundations, their application.

**Role of vegetables in human nutrition** *(Takácsné Hájos Mária CSc)*
Bioactive substances in vegetables are of key importance in a healthy diet, so more conscious elements need to be used to select the right food ingredient. It is necessary to know the role of different plant species and varieties in the diet, as well as the cultivation method that provides the most valuable raw material possible.
Within the framework of the subject, it becomes known which species, when and in what state of maturity must be consumed in order for its role in nutrition to be as favourable as possible. Assessing the relationship between cultivation technology and crop quality can provide basic guidance on how to choose a raw material so that the food consumed has a 'value' in maintaining health.
The subject describes various vegetable plant species and their role in mineral supplementation, increasing fiber intake, supplementing vitamins and other bioactive substances, and energy input and building nutrients.
We also evaluate the effect of storage on the development of content indices in the most important vegetable plant species. The possible dangers of consuming imported vegetables due to the cultivation technology used and the appropriate picking time for transport are also described.
Based on this information, the choice of vegetable raw material may become conscious, which takes into account the specific cultivation method and period, so that the best quality vegetables are consumed.

**Element specification methods in agriculture** *(Kovács Béla PhD)*
The aim of the course is to enable PhD students to get acquainted with the related analytical measurement methods that can be considered as a further development of modern element analysis methods (separation methods + spectrometric methods), the subject should get acquainted with the most important element specification methods and knowledge required for food and food production. The task of the subject is also to acquaint the PhD students with the grouping and applicability of the connected analytical systems. The course details each of the related techniques (HPLC-UV / VIS, HPLC-DAD, HPLC-ICP-MS, HPLC-MS, GC-MS). It covers the significance and process of speciation analytics through concrete examples.

The most important knowledge during the teaching of the subject is the following:

Classification of related techniques. Separation and detection possibilities of element speciation test methods. Comparison of advantages and disadvantages of elemental speciation test methods. Possibilities of separation and detection methods for the analysis of organic components. Sampling and sample preparation methods for speciation analysis. Detailed description of the most important connected systems, which are the most common in international practice. Presentation of arsenic species and methods for their determination. Presentation of selenium species and methods for their determination. Presentation of mercury species and methods for their determination. Presentation of tin species and methods of their determination. Presentation of lead species and methods for their determination. Presentation of species of other elements and methods of their determination. Presentation of API ion sources. Description of HPLC-MS as a coupled analytical system.

**Viticulture technology** *(Bihari Zoltán PhD)*
Winemaking begins with the production of quality raw materials. In the first part of the subject, the student gets acquainted with the effects of rational cultivation on must and wine. The subject also deals with the machines and technology of harvesting and grape processing, the role of yeasts and bacteria, the influence of their living conditions, their advantages and disadvantages. Following the fermentation of the must, influencing it, learning about the fermentation defects is the next important topic. After the must has spread, the handling, storage, then bottling and sale of wine are the important topics that the subject deals with. At the end of the course, the connections between wine culture and marketing will also be discussed.

**Insect physiological basics and their application in modern plant protection**
*(Fónagy Adrien DSc)*
To acquaint students with basic knowledge of plant pathology and entomology with the most important knowledge of insect physiology, which can be transposed and applied with possible methods of modern control methods (integrated plant protection: genetic, physical, chemical, biological control devices, etc.).

Contents of the subject: Insects as model animals, its presentation in many ways; Anatomy of insects; Blankets; Digestive system; Breathing; Circulation; Selection; Reproduction, etc .; Neuroendocrinology and basic physiological processes of insects; The main types of insect reproduction; genitals; ovary, ovum, sperm, methods of fertilization; The main types of insect development; Individual development and postembryonic development; Pheromones / fragrances of insects, especially sex pheromones. Biosynthesis of pheromones and their hormonal regulation.

Elaboration of the daily application of the practical applicability of insect physiology. Integrated pest management is the most important. Investigation of new types of pesticides, mainly the effects of sublethal doses on development, reproduction and detoxification enzymes.

**Plant protection chemistry** *(Balláné Kovács Andrea PhD)*
Research and authorization of plant protection products, toxicological testing system. Interpretation of selectivity, persistence and resistance. Physical and chemical properties and biological efficacy of substance forms. Hazards of pesticide poisoning, occupational safety regulations for storage, transport and application. Biochemical basis of pesticide metabolism. Structure of enzymes. Macromolecules “inhibit the synthesis and degradation of carbohydrates, proteins, lipids, nucleic acids.
General characterization and mechanism of action of inorganic and organic fungicides. Characterization and classification of compounds active against animal pests, mechanism of action of compounds active against animal pests. General and special soil disinfectants. Active substances for the protection of stored crops. Growth regulating plant hormones, hormone synthesis inhibitors. Possibilities of inhibiting photosynthesis. Classification of herbicides, mechanism of action.

**Toxicology** *(Prokisch József PhD)*
The aim of the course is to present the conceptual system of toxicology and ecotoxicology. It provides an overview of the various potentially hazardous substances that affect air, water, soil and food, detailing their effects, the extent of their toxicity, and their effects on wildlife and humans. It presents the occurrence of environmental chemicals in air, water, soil, waste, food and feed, describes the limit values set in the standards.

**Mycotoxins in agriculture** *(Pusztahelyi Tünde PhD)*
Aim of the course: To provide doctoral students with a more detailed picture of toxinogenic fungi and their products that are important in food and feeding. On the possibilities of degradation and elimination of the formed toxins, on the methods of studying the toxins, on the physiological effect of the toxins.
Course topic: Overview of toxinogenic fungi and toxin formation (taxonomy, recognition, metabolism). Criteria for fungal development and preconditions for toxin production. Results of new research areas (genomics, proteomics). Major filamentous fungi (Aspergillus, Penicillium, Fusarium) model organisms. Possibilities of biological control against fungi. An overview of the possibilities of biological control, the role of yeasts and lactic acid bacteria. Test methods: HPLC, ELISA, lateral flow, overview of LC / MS methods. During the lectures, students will receive literature from the materials of previously known and recent publications.

**Weed biology, weed management** *(Radócz László CSc)*
Knowledge of weed biology: definition of weed, basic concepts of weed biology, weed damage, life-form system of weeds, their adaptation to the environment. National distribution of weeds, weed collection methods, weed propagation, reproductive biology, allelopathy, herbicide resistance, species knowledge. Weed control knowledge: methods of weed control, integrated weed control, fate of herbicides in the environment. Uptake, translocation, mechanism of action of herbicidal active ingredients, herbicidal formats, application methods. Weed control technology for major crops.

**Plant protection forecasting** *(Tarcali Gábor PhD)*
Forecasting helps farmers decide on the need for protection and the choice of the optimal time by examining the quantitative aspects of population dynamics and epidemiological phenomena, monitoring the development of pests and analysing the ecological conditions that affect them. In this way, it should provide a scientific basis for the implementation of targeted and sensible plant protection practices that meet the challenges of our time.
The concept, tasks, spatial and temporal levels, methodological bases, tools and possibilities of plant protection forecasting; General and special methods used to predict and determine the spread of pathogens, pests, weeds; Forecast with light traps; Operation and main types of pheromone traps; Major forecasting targeting instruments and software; Prediction of polyphagous pests; Forecasting pests of field crops; Prediction of fruit pests; Prediction of grape pests; Prediction of pests of vegetable plants.

**Biological plant protection** *(Radócz László CSc)*
Basic concept of biological control, history and perspectives. Forms of biological control: antagonism, hyperparasitism, hypovirulence. Native species and insect pests. Insect natural enemies. Mass-propagation methods. Tools and methods of biological control. Weed control by biological means. Ecological crop production, ecological Bio farming, Possibilities of integrated plant protection. Use and legislation of bio-preparates.

**Industrial wastes as possible plant nutrients** (Tóth Brigitta, PhD)
A tantárgy oktatásának célja, elsajátítandó (rész)készségek és (rész)kompetenciák:

A levegő és vizeink szennyeződése, az élelmiszerek fertőződése, a talajok termőképességének csökkenése a fenntartható mezőgazdasági termelés fő nehézségeit jelentik. A jövő mezőgazdaságának elsődleges kihívása Európában, hogy hosszú távon biztosítsa állampolgárai részére a biztonságos élelmiszereket, és képes legyen a folyamatosan növekvő igények

kielégítésére fenntartható, gazdaságos, jó minőségű élelmiszer-termeléssel. A célok megvalósításához innovatív növénytermesztés, és a korlátozottan rendelkezésre álló természeti erőforrások, a meg nem újuló tápanyagok, az energiahordozók, a víz hatékonyabb felhasználása, a talajok termőképességének megtartása a mezőgazdálkodás káros környezeti hatásainak a csökkentése szükséges. A műtrágyák alapanyagainak bányászata, a műtrágyák gyártása és kontinensek közötti szállítása rendkívül költséges és üvegházhatású gázok kibocsátásával jár. Mindezek figyelembevételével időszerű és indokolt alternatív növénytáplálási megoldások keresése a jelenleg uralkodó műtrágyázás helyett, vagy mellett, amely a nem megújuló energiaforrások kiaknázásán alapul. A következő évtizedek egyik nagy kihívása ennek a problémának a megoldása, melyet a növekvő népesség és az egyre korlátozott területen folytatandó mezőgazdálkodás is sürget. Ennek egyik ígéretes perspektívájá lehet az újrahasznosított ipari vagy városi (közösségi) hulladékok/melléktermékek használata. Azonban, ezeknek a hulladékoknak és melléktermékeknek a tápanyag „hasznosíthatósága" és mobilizációja korlátozott. Továbbá, a szervetlen (nehézfémek) vagy szerves szennyezőanyagok további korlátozó tényezőt jelenthetnek a mezőgazdasági gyakorlatban.
A tárgy célja megismertetni az érdeklődő hallgatókkal, a különféle gyártási folyamatok során keletkező hulladékokat és melléktermékeket, hogyan lehet felhasználni a növények tápanyag-ellátásában, illetve a felhasználásuknak milyen akadályai, korlátjai lehetnek.

**MAIN AND SECONDARY SUBJECTS OF THE THEORETICAL PART OF THE COMPLEX EXAM**

***Main subjects:***

- Sustainable land use
- Crop production models
- Horticulture and environment

***Secondary subjects***

- Ecological crop production
- Sustainable precision agriculture
- Agricultural meteorology, climate of the plant stock
- Integrated soil use
- Environment friendly mechanisation
- Fruit production
- Role of vegetables in human nutrition
- Environmentally friendly plant protection

**KERPELY KÁLMÁN**
**CROP PRODUCTION AND HORTICULTURAL SCIENCES**
**DOCTORAL SCHOOL**

# E d u c a t i o n a l  a n d  r e s e a r c h  p l a n

## Research Title

**Name**

Supervisor:

Debrecen
2020.

## STRUCTURE OF THE EDUCATIONAL AND RESEARCH PLAN

### *I. Topic outline*

### 1. Justification of the topic

### 2. Objectives

### 3. Semester-based cost plan:

### 4. Schedule of the research work

| Name of the task | Semester I | Semester II | Semester III | Semester IV | Semester V | Semester VI | Semester VII | Semester VIII |
|---|---|---|---|---|---|---|---|---|
| Scientific literature review | | | | | | | | |
| Data collection | | | | | | | | |
| Data analysis, processing | | | | | | | | |
| Model development | | | | | | | | |
| Preparation of the literature review chapter | | | | | | | | |
| Systematization of own results | | | | | | | | |
| Finalisation of the doctoral dissertation | | | | | | | | |
| Application for acquiring PhD degree | | | | | | | | |
| Publication of partial results | | | | | | | | |

### 5. Planned chapters of the dissertation

**II. Training plan – subject schedule**

**Title of the research topic:**

**PhD student's name:**

**Name and scientific degree of the supervisor(s):**

**Training form:** full-time – correspondence training

| Form | Subject | Lecturer | Semester I | Semester II | Semester III | Semester IV | Semester V | Semester VI | Semester VII | Semester VIII | Credit | Lecturer signature |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Numbers of lessons | | | | | | | | | |
| **Obligatory** | 1. Agricultural research methodology | *Csajbók József, PhD* | 28 | | | | | | | | **2** | |
| | 2. Sustainable land use | *Nagy János, DSc* | 14 | 14 | | | | | | | **2** | |
| | 3. Crop models | *Pepó Péter, DSc* | | | 14 | 14 | | | | | **2** | |
| **Compulsorily selected** | 1. | | 14 | 14 | 14 | | | | | | **3** | |
| | 2. | | 14 | 14 | 14 | | | | | | **3** | |
| **Optional** | 1. | | 28 | | | | | | | | **2** | |
| | 2. | | | 28 | | | | | | | **2** | |
| | 3. | | | | 28 | | | | | | **2** | |
| | 4. | | | | | 28 | | | | | **2** | |
| **Total** | | | **7** | **5** | **5** | **3** | **30** | **30** | **30** | **30** | **20** | |
| **Research activity** (max) | | | **23** | **25** | **25** | **27** | **30** | **30** | **30** | **30** | **220** | |
| **Education activity** | | | **0-4** | **0-4** | **0-4** | **0-4** | **0-4** | **0-4** | | | **0-24** | |
| **Total** | | | **30** | **30** | **30** | **30** | **30** | **30** | | | **240** | |

Date:

PhD. student

supervisor(s)

The Educational and Research Plan is approved by the Council of the Doctoral School: yes no

Date:

Head of the Doctoral School