

**National University of Life and Environmental Sciences of Ukraine**

**Department of agrochemistry and quality of plant products**

**“APPROVED”**

Dean of the faculty

\_\_\_\_\_ Taras Yevsyukov

“ \_\_\_\_\_ ” \_\_\_\_\_ 2019.

**CONSIDERED AND APPROVED**

By the collective of the Department  
of agrochemistry and quality  
of plant products  
report № 15, 28.05.2019

Heard of Department

\_\_\_\_\_ A. V. Bykin

## **SYLLABUS OF THE SUBJECT**

# **Soil science and basic of agricultural chemistry** **(agricultural chemistry)**

(назва навчальної дисципліни)

Спеціальність: \_\_\_\_\_ 193 Land management and geodesy

(шифр і назва спеціальності)

Спеціалізація: \_\_\_\_\_

(назва спеціалізації)

Факультет: \_\_\_\_\_ Land Management

(назва факультету)

Kyiv – 2019

## Description of the subject

### Soil science and basic of agricultural chemistry (agricultural chemistry)

(назва)

<b>Field of the science, trend of the training, specialty, educational-qualification level</b>		
Field of the knowledge	Agriculture (шифр і назва)	
Specialty	<u>193 Land management and geodesy</u> (шифр і назва)	
Educational level	_____ bachelor _____ (бакалавр, спеціаліст, магістр)	
<b>Description of the subject</b>		
Kind	selective	
Whole of hours	90	
Amount of ECTS	3	
Amount of moodles	2	
Undergraduate thesis (якщо є в робочому навчальному плані)	_____ (назва)	
Control	exam	
<b>Indexes of the subject for diurnal tuition and for tuition in correspondence course</b>		
	diurnal tuition	tuition in correspondence course
Year of Training	_____ I _____	_____
Semester	_____ II _____	_____
Lectures	_____ 15 _____	_____ год.
Practis hours	_____	_____ год.
Laboratory hours	_____ 15 _____	_____ год.
Individual hours	_____	_____ год.
Individual tasks	_____	_____ год.
Amount of week hours for diurnal tuition: audience hours Individual hours –	36 год.	

### **1. The goal and task of the course**

The goal of agricultural chemistry studying is to develop student's knowledge and abilities of soil fertility increasing and of fertilizers application and of modern analytical methods in the system "soil-plant-fertilizer".

The task of the course is to build up the theoretical knowledge and practical skills of fertilizers application in crop rotation and determination of nutrients cycle on farm

taken into consideration the zones of crop production and plants features and their sorts' characteristics. The knowledge of agricultural chemistry allow to provide the best conditions for plants nutrition taking into account fertilizers properties, their interaction with soil. Using knowledge of agrochemistry future specialist will be able to determine the most effective forms, terms and methods of fertilizers application for soil fertility improvement.

As a result of agricultural chemistry studying **students have to get knowledge about:**

1. state and prospect of agricultural chemicalization in Ukraine and all over the world;
2. chemical composition of plants, characteristics of their nutrition and ways of its regulation;
3. soil properties connected with plant nutrition and fertilizers application;
4. methods of soil chemical melioration for soil fertility improvement;
5. mane types of mineral and organic fertilizers, modes of their manufacture and characteristics of usage; optimum conditions for storage and application;
6. system of fertilization and agricultural chemistry service for soil fertility improvement.

**Students have to be able after mastering the course:**

1. to determine the necessity of chemical melioration realization and calculate the rate of meliorants for correct soil pH;
2. to be able to identify fertilizers and provide optimum conditions for their application for improvement of soil fertility;
3. to calculate rate and define forms and methods of fertilizers application; estimate economic effectiveness of fertilizers application.

## 2. Program and Structure of the course

Name of the moodle and topics	Amount of hours											
	diurnal tuition						tuition in correspondence course					
	whole	include					whole	include				
		1	p	lab		Ind w		1	p	lab		Ind w
1	2	3	4	5	6	7	8	9	10	11	12	13
<b>Module 1.</b> Chemical composition of plants, plant nutrition and methods of it's regulation. The properties of soils												
Topic 1. The properties of soils		2		2								
Topic 2. Soil acidity and Soil chemical melioration (liming and gypsum application)		1										
Topic 3. Chemical composition of plants, plant nutrition and methods of it's		2		2								

regulation												
Whole in module 1		5		4								
<b>Module 2. Fertilizers, their properties and classification</b>												
Topic 1. Soil nitrogen regime and Nitrogen fertilizers		2		2								
Topic 2. Soil phosphorus regime and Phosphate fertilizers. Soil potassium regime and Potassium fertilizers		1		2								
Topic 3. Micronutrient fertilizers and Multinutrient fertilizers		1		2								
Topic 4. Bacterial fertilizers (bio-fertilizers) and growth activators. Organic fertilizers		2		1								
Topic 5. Organic fertilizers for improvement of soil fertility		2		2								
Topic 6. Fertilization system.		2		2								
Whole in module 2		10		11								
<b>Whole</b>		15		15								
Undergraduate thesis _____												
_____		-	-	-		-		-	-	-		-
(якщо є в робочому навчальному плані)												
<b>Whole</b>		15		15								

### 3. Topic of the laboratory classes

№	Topic	Hours
1	Soil testing. The determination of phosphorus using Kirsanov method. Studing of agrochemical map with phosphorus supply of soil Plant analysis.	2
2	Determination of soil pH and its role in land management	2
3	Building soil pH map and grochemical map with phosphorus supply of soil.	2
4	Qualitative analysis of nitrogen fertilizers. Their influence on soil properties	2
5	Qualitative analysis of phosphorus and potassium fertilizers	2
6	Qualitative analysis of multinutrient and microfertilizers Their influence on soil properties	2
7	Balance-sheet method of fertilizers rate determination. Their	2

	influence on soil properties	
8	Land maps and agrochemical maps	2

### 5. Control questions, test blok for determination of the level of the student knowledge

Test questions	
1.	The agrochemical maps
2.	<b>Nitrogen fertilizers and it influence on soil fertility.</b> Classification of the nitrogen fertilizers. Description of the nitrogen fertilizers in every group.

Test blok	
Question 1. Objects of agricultural chemistry are [3 points]:	
1	Plant
2	Animal
3	Fertilizer
4	Soil

Question 2. Fertilizers are used in order to:	
1	To provide better soil conditions for tillage
2	Supplement the natural soil nutrient supply
3	To provide weeds with nutrients
4	To provide better conditions for soil insects.

Question 3. Type of plant nutrition that supply plants with carbon oxide (IV) is:	
1	Leaves nutrition
2	Air nutrition
3	Root nutrition
4	Carbon nutrition

Question 4. Plants nutrients divided into macro- and micronutrients in dependence on:	
1	Radius of the ions that nutrient form
2	Importance of nutrient for plant growth
3	Amount of nutrient in plant roots
4	Amount of nutrient in plant

Question 5. Macroelement, component of proteins, chlorophyll and genes compounds is:	
1	

Question 6. Who much is the concentration of ....in plants?:	
a) nitrogen	1. 1.5-2.0 %
b) phosphorus	2. 0.5-0.7 %
c) potassium	3. 25%
	4. 1-3 %

Question 7. The main indexes for determination of quality of winter wheat grain are [2 points]:	
1	Protein content
2	Fat content
3	Gluten content
4	Sugar content

Question 8. Properties of the soil that are the subject of agricultural chemistry investigations are :	
2	Pryanishnikov
3	Kirsanov
4	Pavlov

Question 9. Which compounds of the phosphorus in the soil is not easy available for plants [2 points]:	
1	$\text{Ca}_3(\text{PO}_4)_2$
2	$\text{K}_2\text{HPO}_4$
3	$\text{Ca}(\text{H}_2\text{PO}_4)_2$
4	$\text{Mg}_3(\text{PO}_4)_3$

Question 10. To determine correctly nutrient content of fertilizers for adequate fertilizers.	
a) nitrogen fertilizers	1. $\text{K}^+$
b) phosphate fertilizers	2. N
c) potassium fertilizers	3. $\text{P}_2\text{O}_5$
	4. $\text{NO}_2$
	5. $\text{PO}_4^-$
	6. $\text{K}_2\text{O}$

### 6. Individual tasks:

1. Fertilizers in a changing world (*history of fertilizers application and present situation*).
2. Fertilizer production and consumption in my country.
3. Fertilizers in the national market
4. Modern devices for agrochemical analysis (elements of precision farming)
5. Tools to diagnose the nutritional status of crops
6. Precision agriculture
7. Site-specific management (variable-rate fertilization). Spatial variability mapping
8. Remote sensing
9. Important factors affecting yields
10. History of agricultural chemistry development
11. Justus von Liebig (1803-1873)
12. D.I. Pryanishnikov and his role in agricultural chemistry development.
13. Contribution of Ukrainian scientist to agricultural chemistry.
14. Contribution of scientists of national agricultural university to agricultural chemistry.
15. Produce quality and human and animal health
16. Importance of visual diagnosis and deficiency symptoms
17. Diagnosis by soil testing
18. Diagnosis by plant analyses
19. Agrochemical characteristics of soils of Ukraine (*soil type or zone for choice*)

20. Influence of liming on microbiological processes in soil and plant protection
21. Nitrogen fertilization and environmental issues
22. Site-specific and real-time N management
23. Importance of leguminous plants as a source of n
24. Phosphorus fertilization and environmental issues
25. Fertilizers storage
26. Fertilizers application to the chosen crop.
27. Fertilization and human health

### 7. Methods of studied

1. visual;
2. laboratory;
3. practice, etc.

### 8. Control

The protection of laboratory results and tests

### 9. Range of the balls for students

National mark	The definition ECTS mark	Student rating, balls
1	3	4
five	<b>Perfectly</b> – test paper are done perfectly with same mistakes	90-100
four	<b>Well done</b> – higher than intermediate level with same mistakes	74-89
	<b>Well</b> – the correct test paper in generally with same blunders	
three	<b>Satisfactory</b> – the test paper are done not bed but it include number of drawbacks	60-73
	<b>Pretty well</b> – the minimal roles are followed	
two	<b>Bed</b> – student has to study for testing	0-59

### The ball allocation for students

Present tests and individual work		Balls	The part pf moodle in students rating
<b>module 1</b>		<b>100</b>	<b>30</b>
T1	The properties of soils	5	
	L1 Soil analysis. The determination of mobile phosphorus using Kirsanov method	10	
T2	Soil chemical melioration (liming and gypsum application)	5	
	LW2 The determination of neutralizing value of liming	10	

		materials for calculation of the rate of lime materials application.		
T3		Chemical composition of plants, plant nutrition and methods of it's regulation	5	
	LW3	Building soil pH map and geochemical map with phosphorus supply of soil.	10	
	LW4	Module test	60	
<b>module 2</b>			<b>100</b>	<b>40</b>
T4		Fertilizers, their properties and classification. Nitrogen fertilizers	5	
	LW5	Qualitative analysis of nitrogen fertilizers.	10	
T5		Phosphate fertilizers and Potassium fertilizers	5	
T6		Micronutrient fertilizers and Multinutrient fertilizers	5	
T7		Organic fertilizers		
	LW6	Qualitative analysis of phosphorus and potassium fertilizers. Qualitative analysis of multinutrient and microfertilizers	10	
T8		Bacterial fertilizers (bio-fertilizers) and growth activators. Organic fertilizers	5	
T9		Fertilization system.	5	
	LW7	Balance-sheet method of fertilizers rate determination	10	
	LW8	Land maps and agrochemical maps	10	
<b>Модуль 2</b>			45	
Study work			<b>100</b>	<b>70</b>
exam			<b>100</b>	<b>30</b>
Amount			<b>100</b>	<b>100</b>

### 10. Методичне забезпечення

1. Agricultural Chemistry: Manual / М.М. Gorodniy, I.V. Prystash, P.M. Kyveryga. – К, 2007. – 234 p.
2. Agricultural Chemistry: Manual to lecture classes / I. V. Loginova., N. P. Bordyuzha. – К: СОМПРИНТ, 2012. – 75 p.
3. Agrochemical Analysis: Manual to laboratory work / I. V. Loginova., N. P. Bordyuzha. – К: СОМПРИНТ, 2012. – 75 p.

### 11. Рекомендована література

#### Basic literature:

4. Agricultural Chemistry: Manual / М.М. Gorodniy, I.V. Prystash, P.M. Kyveryga. – К, 2007. – 234 p.
5. Agricultural Chemistry: Manual to lecture classes / I. V. Loginova., N. P. Bordyuzha. – К: СОМПРИНТ, 2012. – 75 p.
6. Agrochemical Analysis: Manual to laboratory work / I. V. Loginova., N. P. Bordyuzha. – К: СОМПРИНТ, 2012. – 75 p.
7. Смирнов П.М., Муравин Э.А. Агрохимия. – М.: Агропромиздат, 1991. – 288 с.
8. Радов А.С. и др. Практикум по агрохимии / А.С. Радов, И.В. Пустовойт, А.В. Корольков; Под ред. И.В. Пустового. – М.: Агропромиздат, 1985. – 312 с.

9. Агрохімія: Підручник / М.М. Городній, А. В. Бикін, Л.М. Нагаєвська. – К.: ТОВ “Алефа”, 2003. – 786 с.

10. Лісовал А.П., Макаренко В.М., Кравченко С.М. Система застосування добрив. – К.: Вища шк., 2002. – 318 с.

11. Tisdale S.L., Nelson W.L., Beaton J.D. Soil Fertility and Fertilizers. – New York: Macmillan Publishing Company, 1985. – 754 p.

12. Brady N.C. The nature and properties of soils / Nyle C. Brady, Ray R. Weil. – 13<sup>th</sup> ed. – Upper Saddle River, New Jersey “Prentice Hall”. – 2002. – 960 p.

#### **Internet recourses**

<http://www.fertilizer.com>

US Fertilizer Corporation

<http://www.fertilizer.org/ifa>

International Fertilizer Industry Association

<http://www.efma.org>

European Fertilizer Manufacturers Association

<http://www.ifdc.org>

An International Center for Soil Fertility and Agricultural Development

<http://fao.org>

Food Agricultural Organization

<http://www.tfi.org>

The Fertilizer Institute

#### **Additional literature**

1. Власюк П.А. Биологические элементы в жизни растений. – К.: Наукова думка, 1969. – 460 с.

2. Довідник працівника агрохімслужби / Під ред. Б.С. Носка. – К.: Урожай, 1986.

3. Прянишников Д.А. Избранные сочинения: В 3 т. – М.: Сельхозиздат, 1963. – 2105 с.

4. Nutritional Disorders of Plants: Development, Visual and Analytical Diagnosis / Ed. by Werner Bergmann. – Jena; Stuttgart; New York: G. Fisher, 1992. – 741 p.

5. Miller R.W., Gardiner D.T. Soil in our environment. – New Jersey, 2001. – 750 p.

6. Soils in our environment / Raymon W. Miller, Duane T. Gardiner. – 9<sup>th</sup> ed., 1997.

7. Soils: an Introduction / Michael J. Singer, Donald N. Munns. – Upper Saddle River, New Jersey “Prentice Hall”. – 1996. – 480 p.

#### **12. Інформаційні ресурси**

1. Computer programs: AGROSTAT, PANORAMA/

**SUBJECT-MATTER**  
**of lectures on agricultural chemistry**  
**for the 1-nd year students of the Land Management Faculty**

**LECTURE 1 (2 hours)**

**Introduction.** World fertilizer production and consumption. Status and prospects for organic and mineral fertilizers application. The role of organic and mineral fertilizers in crop yield increasing, quality improvement, maintenance and increasing of soil fertility

The objective of agricultural chemistry and its place in the system of sciences. Assignments of agrochemistry. Brief history of the agricultural chemistry development and contribution of foreign and Ukrainian scientists to the development of views to plant nutrition and fertilization of crops.

Theory of plants productiveness. Main laws of agricultural chemistry and their role to increase fertilizer use efficiency.

**Agrochemical, agrophysical and biological properties of soil in connection with plant nutrition and fertilization.** Soil composition. Soil phases and their interrelation. Properties of mineral and organic soil parts. Forms of compounds in the soil that contain main nutrients. Soil organic matter. Humus and its necessity for soil fertility and plant nutrition. Ways of humus losses prevention.

Soil absorbing capacity, its types (mechanical, physical, biological, chemical, physico-chemical) and role in soil-fertilizers interaction and plant nutrition. Soil adsorbing complex, its composition and structure in different soil types.

Agrochemical characteristics of main soil types and fertilization effectiveness. Supply of nutrient for plants on different soils. Agrochemical maps, their making and their using.

**LECTURE 2 (2 hours)**

**Soil chemical melioration (liming and gypsum application).** Soil pH. Soil classification depending on soil solution pH. Reaction of crops on soil acidity and effectiveness of liming.

Influence of lime on neutralization of soil acidity and improvement of soil agrochemical and agrophysical properties.

Liming materials: hard, soft calcareous rocks and carbonated industrial wastes. Neutralizing value or calcium carbonate equivalent of liming materials. Determination of lime requirement. Lime rate calculation. Lime activity duration. Terms of lime application and methods of placement.

Gypsum application on alkaline soils and solonetz. Gypsum interaction with soil and improvement of soil physical-chemical and agrochemical properties. Gypsum materials used for application.

Development of estimative documentaries for soil chemical melioration. Economical estimation of chemical melioration.

**LECTURE 3 (2 hours)**

**Chemical composition of plants, plant nutrition and methods of its regulation.** Plants nutrition, its types. Air and root nutrition.

Chemical composition of plants and factors that determine it. Plant production quality indices and fertilizers influence on biological quality of agricultural production.

Nutrients essential for normal growth and development of plants. Macro- and microelements. Role of nutrients in plant nutrition. Source of nutrients. Dynamics of nutrients utilization during the vegetation period of plants.

Diagnosis of plant nutrition and fertilizers requirements. Plant observation, plant tissue testing, plant analysis, soil testing, express-diagnosis and tools to diagnose the nutritional status of crops.

#### **LECTURE 4 (2 hours)**

**Fertilizers, their properties and classification.** Fertilizers classification by origin (organic, mineral and bio-fertilizers), by method of production (natural, industrial), by mode of action (direct and indirect; quick-acting, slow-acting), by physical state (solid, liquid and gaseous), by the number of nutrients (single-nutrient or straight fertilizers, and multinutrient fertilizers). Fertilizers types and forms. Active substance of fertilizers.

Fertilizer dose and rate. Terms of fertilization [basal application, preplant fertilization, fertilizers application at sowing or planting, top-dressing (side-dressing and foliar dressing)]. Methods of fertilizers placement [overall application (broadcasting, sprinkler application, powdering) and localized fertilizers placement (row or band placement), fertigation]. Time of fertilizers application.

**Nitrogen fertilizers.** Functional role of nitrogen in plant growth and development. Plants nitrogen deficiency symptoms. Nitrogen sources for plant nutrition. Nitrogen reserves in soil. Importance of nitrogen biological fixation and leguminous plants for soil nitrogen enrichment. Nitrogen losses.

Nitrogen fertilizers manufacture. Forms of nitrogen fertilizers and main fertilizer nitrogen materials: ammoniacal (anhydrous ammonia, aqua ammonia); ammonium (ammonium sulphate, ammonium chloride); nitrate (sodium nitrate, calcium nitrate); ammonium–nitrate (ammonium nitrate, ammonium nitrate-sulfate); amide (urea). Urea-ammonium nitrate (UAN solutions). Nitrogen fertilizers interaction with a soil. Nitrogen fertilizers application to different crops on different soils. Technology of nitrogen fertilizers application. Recommended fertilizer rates for different crops. Determination of the necessity of nitrogen fertilizers application in top-dressing. Means for increasing nitrogen fertilizers effectiveness. Influence of nitrogen on crop yield and soil properties. Economical estimation of nitrogen fertilizers application effectiveness.

#### **LECTURE 5 (2 hours)**

**Phosphate fertilizers.** Functional role of phosphorus for plants growth. Phosphorus sources for plants. Phosphorus uptake by plants. Phosphorus deficiency symptoms. Phosphorus in soil. Forms of phosphorus in soil and their importance for plant nutrition. Phosphate retrogradation.

Rock phosphate ores used for phosphate fertilizers manufacture (phosphorite, apatite), world and Ukrainian deposits. Phosphate fertilizers classification by the number of substituted atoms of hydrogen in phosphoric acid and by solubility in different solvents. Groups of phosphate fertilizers: water-soluble (monosubstituted): ordinary superphosphate, triple or concentrated superphosphate; citrate-soluble (disubstituted): dicalcium phosphate or precipitate; citric acid soluble (disubstituted):

basic slag or thomas slag, phosphate slag; not-readily soluble (trisubstituted): rock phosphate. Interaction of phosphate fertilizers with soil and fertilization effectiveness increasing on different soil types of Ukraine. Fertilization rates and technologies of phosphate fertilizers application to different crops.

Importance of phosphate fertilizers for improvement of plant nutrition, yield increasing, and high quality of production obtaining and land estimation. Economical estimation of phosphate fertilizers application effectiveness.

**Potassium fertilizers.** Functional role of potassium for plant nutrition. Sources of potassium and its uptake by plants. Potassium plants deficiency symptoms. Potassium in soil. Forms of potassium in soil and their importance for plant nutrition.

Potassium ores deposits. Potassium fertilizers manufacture. Groups of potassium fertilizers depending on mode of production: row potassium salts; concentrated (potassium chloride or muriate of potash, potassium sulfate, sulfate of potash magnesia, potassium carbonate); composite (30% and 40% potassium salt, potassium electrolyte). Chlorinated and chlorine-free potassium fertilizers, their effectiveness for crops in different soil-climatic zones of Ukraine. Ways of fertilization effectiveness increasing. Fertilization rates and technology of potassium fertilizers application to different crops.

Influence of potassium fertilizers on crop yield increasing, and quality improvement and soil properties. Economical estimation of potassium fertilizers application effectiveness.

#### **LECTURE 6 (2 hours)**

**Micronutrient fertilizers.** Functional role of zinc, copper, manganese, molybdenum, cobalt and boron in plant growth. Sources of micronutrients and their uptake by plants. Diagnostic of plant supply with micronutrients and deficiency symptoms.

Micronutrient fertilizers classification. Assortment of micronutrient fertilizers (zinc, copper, manganese, molybdenum, cobalt and boron fertilizers) and effective technology of their application. Micronutrient chelates.

Micronutrient fertilizers efficiency to crops on different soil types of Ukraine and their influence on crop yield and quality.

**Multinutrient fertilizers.** The importance of balanced fertilization for normal plants growth and development and increasing of their resistance to stress situations.

Multinutrient fertilizers manufacture and classification: by the number of nutrients (double, triple); by the mode of production: complex (monoammonium phosphate, diammonium phosphate, ammonium polyphosphate, potassium nitrate), compound (nitrophos, nitrophoska, nitroammophos, nitroammophoska, ammoniated superphosphates), mixed or blended fertilizers. Multinutrient fertilizers with micronutrients. Possibilities of mixing fertilizers.

Technology of multinutrient fertilizers application and their advantages comparing with strait fertilizers. Economical estimation of multinutrient fertilizers application effectiveness.

#### **LECTURE 7 (2 hours)**

**Bacterial fertilizers (bio-fertilizers) and growth activators.** Importance of soil microorganisms. Microbial seed inoculants for leguminous plants (rhizotrophin,

nitragin) and factors that influence nitrogen fixation effectiveness. Bio-fertilizers based on free-living microorganisms (phyzophil, azotobacterin). Phosphate-mobilizing microorganisms (phosphobacterins). Technology of bio-fertilizers application.

Use of growth activators in plant production for plant growth guidance.

### **LECTURE 8 (2 hours)**

**Organic fertilizers.** Role of organic fertilizers for soil fertility improvement, improvement of the conditions of plant growth and rising the effectiveness of mineral fertilizers. Advantages of organic-mineral fertilization of crops.

**Manure** (farmyard or stable manure, slurry or litterless manure), its composition and characteristics of application.

Litter materials and importance of litter. Manure depending on the rate of decomposition: fresh manure, semi-rotted manure, rotted manure, fine manure. Manure storage: field dung-heap, dung-yard. Conditions of manure storage. Technology of manure application in different soil-climatic zones of Ukraine to different crops.

Litterless manure, characteristics of its storage, transportation and application.

**Liquid manure**, its chemical composition and technology of application. Decreasing of nitrogen losses from liquid manure.

**Poultry manure**, its composition, storage and coefficients for utilization of nutrients by crops. Application of poultry manure to different crops.

**Sapropel**, its composition and application to different crops.

**Peat**, types and kinds of peat, botanical composition and content of nutrients. Peat properties (ash percentage, moisture capacity, absorption capacity). Peat application in agriculture.

**Composts**, importance of organic sources composting. Importance of microbiological processes in nutrient transformation in available for plants forms. Composts based on peat and other agricultural and industrial wastes. Their importance for crop fertilization.

**Vermicompost** and liquid biohumus. Technology of production and application.

**Green manure** and its role for soil enrichment by organic matter, nitrogen and other nutrients. Crops used as green manure. Forms of green manure (fool, mowing, stubble). Technology of green manure growing and application.

### **LECTURE 9 (2 hours)**

**Fertilization system.** Brief characteristics of nutrition and fertilization of main crops (weed, rye, barely, corn, sugar beet, potato, flax, pea, lupine, alfalfa). Fertilization of vegetables and fruit. Fertilization under irrigation.

Idea of nutrients balance in agriculture. Items of losses and income.

Fertilizers application rates determination (average recommended rates, balance-sheet method).

Influence of fertilization system on soil properties and land estimation and land management.