THEME 12
AGRICULTURAL ECOSYSTEMS

Motivational statement

In the process of interaction with nature, humanity has constantly solved the primary task of life support — the production of food (the only source of human energy). A person receives quite a lot of different types of products from natural ecosystems. Nevertheless, the main source of funds to meet its needs is agriculture. The process of transition from gathering to primitive, and subsequently to more advanced farming systems, to more advanced farming in general, stimulating the growth of food production, contributed to an increase in the importance of the agricultural sector in the formation of primary biological products. This greatly favored the growth of the world's population. Human agricultural activity is changing natural ecosystems. In addition, a person is able to form artificial ecosystems and maintain their existence in order to obtain agricultural products. These artificial ecosystems are called agroecosystems.

The objective: to form knowledge about the structure of ecosystems, to learn how to make a description of natural and artificial ecosystems, to explain the differences between them and their significance; to know the principles of sustainable functioning and methods of conservation of agroecosystems resources.

Questions for discussion

1. Agroecosystem, agrocenosis - definitions of concepts, examples. Basic requirements for agroecosystems: stability, plasticity, inertia.
2. Agricultural landscape: concept, negative impact of human activity, directions of optimization.
3. Principles of sustainable functioning and methods of conservation of agroecosystems resources.
4. Differences between natural and agricultural ecosystems.
5. The structure of the agroecosystem.
6. Classification of agroecosystems (by types of land use, by reproduction of soil fertility, by energy balance).
7. Soil-biotic complex (SBC) as the basis of agroecosystems.

Independent work of students

Choose one answer

01. Why can't a field sown with cultivated plants be considered a natural ecosystem?

1) there are no food chains
2) there is no circulation of substances

3) in addition to solar, additional energy is used
4) plants are not arranged in tiers in space
02. Agrocenosis are characterized by
1) the dominance of monoculture
2) reducing the number of pests
3) the diversity of the types of organisms included in them
4) reducing the competitiveness of cultivated plants
03. The peculiarity of the rye field as an agroecosystem
1) a large number of species
2) lack of reducers
3) long power supply chains
4) short-term existence
04. An ecosystem in which artificial selection is carried out, aimed at increasing the productivity of agricultural crops, and the effect of natural selection is weakened
1) agrocenosis
2) nature reserve
3) biogeocenosis
4) national park
05. The similarity of artificial and natural ecosystems is that they
1) contain the same number of links in the power supply networks
2) have the same productivity of plant biomass
3) cannot exist without human participation
4) contain the same functional groups of organisms
06. The agroecosystem of the orchard differs from the ecosystem of the oak grove
1) absence of pests and parasites
2) longer power circuits
3) less stability
4) closed circulation of substances
07. Agrocenois include
1) meadow clover community
2) field with seeded peas
3) forest community
4) meadow cereal community
08. Agroecosystems are less stable than ecosystems, since they
1) there are no producers and reducers
2) limited species composition of plants
3) animals occupy the first trophic level
4) a closed cycle of substances and energy transformations

09. Introduction of agrocenosis of legumes into crop rotations contributes to
1) reduction of acreage
2) reducing soil erosion
3) accumulation of nitrogen in the soil
4) enrichment of the soil with phosphorus compounds
10. The introduction of fertilizers into the soil is accompanied by pollution of the plant habitat when
1) fertilization in autumn
2) fertilization in early spring
3) improper tillage
4) violation of norms and terms of fertilization
11. An example of agrocenosis can be
1) wooded meadow
2) wheat field
3) water-meadow
4) floodplain of the river
12. In which ecosystem is the circulation of substances open?
1) feather grass plain
2) wheat field
3) coniferous forest
4) oak grove

Reference material

Agroecosystem is an ecological system that unites a piece of territory (geographical landscape) occupied by an economy producing agricultural products. The agroecosystem includes: soils with their populations (animals, algae, fungi, bacteria); fields-agrocenoses; livestock; fragments of natural and semi-natural ecosystems (forests, natural forage lands, swamps, reservoirs); man.

The main features of the agroecosystem are determined by a person who stands at the top of the ecological pyramid and is interested in obtaining the maximum amount of agricultural products.

Agroecosystems include fields, orchards, vineyards, protective forest strips, etc. Without human support, agroecosystems quickly disintegrate, returning to their natural state.

The components of the agroecosystem are agricultural lands on which grain, tilled, fodder and industrial crops are grown, as well as meadows and pastures.

The basis of agroecosystems are *agrocenoses.*

Agrocenosis (Greek: agros – field) are biocenoses on agricultural land. The main elements of agrocenosis in agricultural ecosystems are:

1) cultivated plants sown or planted by man;
2) weeds;
3) microorganisms of the rhizosphere of cultivated and weed plants;
4) nodule bacteria on the roots of legumes that bind free nitrogen in the air;
5) mycorrhizal fungi on the roots of higher plants;
6) bacteria, fungi, actinomycetes, algae, free-living in the soil;
7) invertebrates living in the soil and on plants;
8) vertebrates (rodents, birds, etc.) living in soil and crops;
9) fungi, bacteria, viruses-parasites (semi-parasites) of cultivated and weeds;
10) bacteriophages are parasites of microorganisms.

Currently, about ten percent of the land is occupied by agrocenoses. In agrocenoses, the vegetation cover is represented by one or few species. The replacement of a complex vegetation cover with a monoculture leads to a sharp restructuring of the phytophagous complex. Species unable to feed on cultivated plants may disappear. In agrocenoses, the number of entomophages is also sharply decreasing.

Agrocenoses are regulated by human activity. They have high productivity, but low environmental sustainability. In the formation of agroecosystems, their *stability* is of fundamental importance – the ability to preserve and maintain the value of their parameters and structures in space and time without changing the nature of their functioning. *Parameters of* agroecosystem *stability* are functions, modes and properties of soil; structure, organization and productivity of agrophytocenosis; structure and organization of microbial community; intensity and balance of biogeochemical cycle; information flows.

Agroecosystems must have *plasticity*, which means their ability to return to the previous area of stable equilibrium after temporary exposure to a natural or anthropogenic factor; *inertia*, due to which internal connections are preserved during the transition from one area of stable equilibrium to another. The preservation and improvement of soil fertility is a central link in ensuring the sustainability of agroecosystems.

An agricultural landscape is an ecosystem formed as a result of the agricultural transformation of the natural landscape. Thus, an agricultural landscape is understood as a landscape, in most of which natural vegetation has been replaced by crops and plantings of agricultural plants.

Human activity leads to significant and sustainable changes in the natural environment. In agroecosystems, these include the processes of erosion and deflation; contamination of soils and natural waters with chemicals washed out of mineral fertilizers; eutrophication of reservoirs; compaction, acidification and reduction of biological activity of soils; changes in species composition, abundance

and distribution of flora and fauna, etc. In this regard, there is an obvious need for a system of environmental stabilizing measures.

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Optimization of the agricultural landscape is a set of measures to preserve or modify existing and form new connections between various components of the landscape in order to use it rationally, preserve useful properties and prevent their possible loss, establish the fullest possible correspondence of the natural potential of the landscape to the socio–economic functions assigned to it by a person.

In order to achieve optimal functioning of agricultural systems adapted to specific conditions, it is important to observe the principle of adequacy, interconnection and subordination of natural, technological, economic and social characteristics.

The ecological and social significance of agricultural landscapes is determined by their role in the life support of society and in regulating the quality of the environment. The intensity of the use of biological resources of agricultural landscapes should be limited by their ability to renew.

The agrosphere is a global system that unites the entire territory of the Earth transformed by human agricultural activity.

Principles of sustainable functioning of agroecosystems

Table 1

Agroecosystem resources and methods of their conservation

Agroecosystem resources	Resource conservation methods
Renewable: – humus content in the soil	Soil protection tillage; saturation of crop rotations with soil-restoring crops; full use of manure
– nitrogen content in the soil	Activation of biological nitrogen fixation processes; application of manure and nitrogen mineral fertilizers
–hydrochemical and hydrological regimes	Rationing of water intakes for irrigation; exclusion of drainage of swamps; prevention of agricultural and man-made soil pollution

Non - renewable: – stocks of fluorine, potassium and other elements of nutrition;	Application of mineral fertilizers
– biodiversity	Reduction of arable land area; reduction of pasture loads; rational use of forest plantations; use of restorative successions

Distinctive features of agroecosystems

Natural systems and agroecosystems have their own energy flows and the possibility of its accumulation, internal and external cycles of substances, have the ability to regulate these processes, which differ significantly from each other.

The first difference between natural and artificial ecosystems (agroecosystems) ***is in the different direction of selection.*** Natural selection, rejecting non–viable forms of organisms and their communities, leads the organization of natural ecosystems to their fundamental property - sustainability. With a lack of light, heat and moisture, nutrients, those competing species that are able to go through the entire life cycle and leave offspring survive. Agrobiocenoses are outside the sphere of natural selection, these systems are created and maintained by humans. Artificial selection is primarily aimed at increasing the yield of agricultural crops, and the yield is not associated with resistance to adverse factors.

The second difference is related to the incoming energy. Natural ecosystems use the only source of energy – the sun. The efficiency of using solar energy is small, but natural ecosystems sustainably exist on this amount of energy, transforming it in various food chains. Agrobiocenoses, along with solar energy, receive additional. The share of anthropogenic energy is 5-10% of the total. Such energy includes: human muscular efforts, fertilizers, pesticides, irrigation, agricultural machinery, etc. Energy investments are always accompanied by material ones, which affects the biological cycle in agrocenoses. In general, the efficiency of good sowing during the growing season does not exceed 1.0–4.0%.

The third difference is the diversity of the ecological composition of the phytocenosis. The diversity of the ecological composition of the phytocenosis ensures the stability of the production process with fluctuations in weather conditions in different years. The oppression of some plants in natural ecosystems leads to an increase in the productivity of others. As a result, the ability to create products in different years remains. The agrocenosis of field crops is a monodominant, single–variety community. The effect of adverse factors is equally reflected in all plants of the agrocenosis. The inhibition of the growth and

development of one crop cannot be compensated by the increased growth of other plants. As a result, the stability of the agrocenosis is lower than in natural ecosystems.

The fourth difference is the presence of plants with different phenological rhythms. The presence of a wide range of plants with different phenological rhythms allows natural ecosystems to carry out the production process continuously throughout the growing season, most fully and economically spending resources of heat, moisture and nutrients.

In agroecosystems, the growing season of cultivated plants is shorter than the growing season. In agrobiocenosis, plant growth is simultaneous and the sequence of development stages is largely synchronous. Therefore, the time of interaction of plants and their residues with the soil is much shorter than in natural systems, which negatively affects the metabolic processes in the system. Aboveground plant residues enter the soil for a short period of time, only in late summer and early autumn, their mineralization is carried out only in the next season, which negatively affects the level of soil fertility.

Fifth, one of the most significant differences between natural ecosystems and agroecosystems ***is the degree of compensation of the cycle within the ecosystem.***

In natural ecosystems, the entry of matter into the cycle for a certain period is on average approximately equal to the exit of matter from the cycle.

Anthropogenic impact violates the compensation (closure) of the biological cycle. In agroecosystems, some substances are permanently removed from the ecosystem. In agrocenoses with plant products, 50.0–60.0% of organic matter is removed. Even the application of fertilizers cannot compensate for the batteries carried out with the harvest.

A decrease in the humus content worsens the conditions for the development of beneficial microflora, including "soil-cleaning", contributes to the loss of reserves of subsurface energy, nutrition elements, promotes the strengthening of the process of flushing and leaching, that is, causes the degradation of the basis.

The sixth difference is that natural systems are autoregulatory, agroecosystems are man–controlled. A person in agroecosystems controls or changes the influence of natural factors. In this connection, it is necessary to find conditions for increasing crop yields with minimal costs of matter and energy, at which soil fertility was preserved and increased.

Structure of the agroecosystem

Agroecosystem is an autotrophic ecosystem, the main source of energy for which is the sun. The additional (anthropogenic) energy that a person uses when

cultivating the soil and spent on the production of tractors, fertilizers, pesticides, etc., does not exceed 1% of the solar energy absorbed by the agroecosystem.

Like a natural ecosystem, the agroecosystem consists of organisms of three main trophic groups: *producers, consumers and decomposers (reducers)*.

Producers in the agroecosystem are cultivated plants, grasses of hayfields and pastures, trees of gardens, forest plantations and natural forests that are part of it. The producers are also the satellites of cultivated plants – weeds.

Consumers in the agroecosystem – humans and farm animals. The consumers also include pests of field crops (from insects to ground squirrels and hamsters); parasites (often dangerous for farm animals); useful insects (predatory and pollinators); birds, symbiotic organisms (mycorrhizal fungi and nitrogen fixing bacteria).

Animal detritophages crush plant residues and facilitate the activity of bacteria. The role of earthworms is especially important. The soil that has passed through the digestive system of the earthworm with plant residues is glued into dense lumps, which improves its structure. These lumps are enriched with potassium, phosphorus and nitrogen in the form of compounds available to plants. In addition, worms, breaking through the passages, loosen the soil and facilitate the penetration of roots into it. In well-watered soil, the biomass of worms can be up to 10-20 tons per 1 ha. There are special farms where earthworms are bred, which are brought to the fields to increase the yield.

Decomposers (reducers) in the agroecosystem are mainly bacteria. They maintain soil fertility by turning crop residues into humus, and humus and manure introduced into the fields into simpler organic and mineral substances available to plants.

However, among the decomposers there are not only soil fertility restorers, but also its destroyers. Nitrifying and denitrifying bacteria convert ammonium forms of nitrogen into nitrates, which are easily washed out of the soil, and nitrogen gas escaping into the atmosphere.

The energy entering the agroecosystem is transmitted through food chains. There are two main (main) food chains in the agroecosystem: plant – man; plant – cattle – man.

Classification of agroecosystems

There are **five types of land use**, for each of which agroecosystems are classified.

1. Agricultural or field land use – *rain-fed, irrigated and melon agroecosystems* (rotation of cereals, legumes, fodder, root crops, vegetables, industrial and medicinal crops).

2. Plantation and garden land use - *plantation agroecosystems* (tea bush, cocoa tree, coffee tree, sugar cane), *garden agroecosystems* (fruit orchards, berry fields, vineyards).

3. Pasture land use – *pasture agroecosystems* (driving pastures: tundra, desert, mountain; forest pastures; improved pastures: hayfields, cultivated meadows).

4. Mixed land use – *mixed agroecosystems* characterized by an equivalent ratio and combination of several types of land use, as well as processes for obtaining both primary and secondary biological products.

5. Land use for the production of secondary biological products – *agro-industrial ecosystems* (territories of intensive "industrialized" production of milk, meat, eggs and other products based on the prevailing processes of supplying the system with matter and energy from the outside).

According to the reproduction of soil fertility, there are three basic types of agroecosystems:

1. The nature-intensive type is characterized by incomplete reproduction of natural fertility, which leads to a drop in its level.

2. The nature conservation type is characterized by the simple reproduction of natural fertility and, as a consequence, the preservation of its level.

3. The nature-improving type is aimed at expanded reproduction and increasing the level of natural fertility.

Currently, the nature-intensive type predominates. It should be noted that in proportion to the type of reproduction of soil fertility, the efficiency of anthropogenic energy introduced into agroecosystems changes.

The energy balance of ecosystems, which varies depending on the climatic zone, objectively determines the formation of ecosystems' adaptability to the "optimal" absorption of radiant energy possible under specific conditions. The adaptability of the energy balance of the ecosystem, corresponding to the energy consumption for heat exchange and transpiration, everywhere determines the productive efficiency of both natural and artificial cenotic formations.

The energy features of various natural zones of the planet allow us to distinguish 5 main (global) types of agroecosystems:

1. Tropical type. It is characterized by a high supply of heat, contributing to continuous vegetation. Agriculture is mainly carried out on the basis of the functioning of agroecosystems with a predominance of perennial crops (pineapples, bananas, cocoa, coffee, perennial cotton, etc.). Annual crops here yield several harvests per year. A special feature is the continuous need for the

investment of anthropogenic energy due to the constant conduct of field work throughout the year.

For agroecosystems of this type, the equivalence of natural and anthropogenic processes of mass and energy exchange is inherent.

2. Subtropical type. The intensity of anthropogenic flows of substances and energy is less; the discreteness and dispersion of these flows are manifested. Basically, it is characterized by the presence of two growing seasons – summer and winter. Perennial plants grow that have a well-defined period of vegetative rest (grapes, walnuts, tea, etc.). Annual plants of the summer period are represented by corn, rice, soy, cotton, etc.

3. Moderate type. Agroecosystems are characterized by only one (summer) growing season and a long ("non-working") period of winter rest. There is a very high demand for the investment of anthropogenic energy in spring, summer and the first half4.

4. Polar type. Agriculture is of a focal nature. Agroecosystems are significantly limited geographically and by types of cultivated crops (leafy vegetables, barley, some root crops, early potatoes). of autumn.

5. Arctic type. There are no agroecosystems of open ground. Cultivation of cultivated plants is excluded due to the very low temperatures of the warm period: in the summer months there are long cold spells with negative temperatures. It is possible to use closed ground.

Classification of agroecosystems by energy criterion

Table 2

Global type of agroecosystem	Characteristic	The energy exchange features
Tropical type	High availability of heat, the predominance of perennial crops, several harvests per year (the predominant perennial crops are pineapples, cocoa, coffee).	Equivalent to natural energy exchange and mass exchange
Subtropical type	Two vegetation periods (winter and summer) are characteristic (there is a discreteness and dispersion of the flows of matter and energy). Perennial crops with a pronounced dormancy period prevail (the predominant perennial crops are tea, grapes, walnuts, citrus fruits).	Some additional energy investments are needed.
Moderate type	Only one growing season is	Only one growing

	characteristic, the winter dormancy period is quite long. High demand for the investment of anthropogenic energy. The predominant perennial crops are pome and stone fruit.	season is characteristic, the winter dormancy period is quite long. High demand for the investment of anthropogenic energy. The predominant perennial crops are pome and stone fruit.
Polar	Agriculture of a focal nature (small fields with rapidly maturing crops). There is a very high need for the investment of anthropogenic energy. The predominant perennial crops are sea buckthorn, berry bushes.	Significant differences in the flows of energy and matter.
Arctic	Farming only in the closed ground. Exists only with additional anthropogenic energy.	Radical differences in the flows of energy and matter.

On the territory of modern Russia, agroecosystems of a moderate type are dominant with all the ensuing requirements for the organization of their rational functioning.

Soil-biotic complex (SBC) as the basis of agroecosystems

Soil (V.V. Dokuchaev) is an independent natural mineral–organic body formed from the surface layers of rock as a result of the impact of living organisms on them in certain climatic conditions. The inherent property of the soil is fertility. Emphasizing this basic property of the soil, V.R. Williams called the soil a loose surface horizon of the terrestrial globe, capable of producing a crop of plants.

Soil fertility is its ability to meet the needs of plants for nutrients, air, biotic and physico—chemical environment, including thermal regime, providing biogenic productivity of vegetation.

Edaphic factors (from Greek. edaphos — soil) — soil conditions of plant growth. Are divided into:

-chemical - soil reaction, soil salt regime, elementary chemical composition of soil, exchange capacity and composition of exchange cations;

- physical - water, air and thermal regimes, density and thickness of the soil, its granulometric composition, structure, etc.;

- biological - plant and animal organisms inhabiting the soil (Khrustalev, Matishev, 1996).

The soil consists of solid, liquid, gaseous and living parts, or phases. Their ratio is not the same not only in different soils, but also in different horizons of the same soil. Naturally, there is a decrease in the content of organic substances and living organisms from the upper horizons of soils to the lower ones and an increase in the components of the parent rock from the lower horizons to the upper ones.

The composition of the soil includes four important components:

1) mineral base (50-60% of the total volume);

2) organic matter (up to 10%);

3) air (15-25%);

4) water (25-35%).

The mineral part of the solid phase of the soil consists of the parent rock crushed to varying degrees, which accounts for 80-97% of the solid phase of most soils. As a result of weathering, the simplest compounds are formed in it, easily soluble in water. The mineralogical composition of the solid part of the soil largely determines its fertility. The composition of mineral compounds includes the following chemical elements: Si, Al, Fe, K, N, Mg, Ca, P, S; significantly less trace elements are contained: Cu, Mo, I, B, F, Pb, etc.

The organic part of the solid phase of the soil consists of undecomposed and slightly decomposed remains of plants, animals, insects, bacteria, decomposition products of plant residues by bacteria and fungi, various organic acids and their salts.

The replenishment of the soil with organic matter occurs due to the decomposition of plant residues (fallen leaves, stubble, plant roots), the introduction of manure, peat, organic-mineral compost, green mass of plants grown on green fertilizer into the soil.

Decomposition of organic residues is associated with the release of heat.

The liquid fraction, that is, the soil solution, is an active component of the soil that carries out the transfer of substances inside it, removal from the soil and supply of plants with water and dissolved nutrients. It usually contains ions, molecules, colloids and larger particles, sometimes turning into a suspension. The composition of the liquid fraction includes: water with organic and mineral compounds dissolved in it. Water in the soil contains from 0.1 to 60% of the weight of absolutely dry soil. The liquid part participates in the supply of plants with water and dissolved nutrients. Soil moisture is retained in the spaces between its particles. Part of the water seeps through the soil, that is, passes through the soil

profile, forming groundwater; the rest of the water remains in the soil due to surface tension forces or is adsorbed on the surfaces of quartz crystals or clay.

Air, as well as water, is retained in the soil in the intervals between its particles. This soil air, or the gaseous part of the soil, fills the pores that are not occupied by water. The amount and composition of soil air, which includes nitrogen, oxygen, carbon dioxide, volatile organic compounds and others, are unstable and are determined by the nature of many chemical, biochemical, biological processes occurring in the soil. For example, the amount of carbon dioxide varies significantly in the composition of soil air depending on the annual and daily cycle. The fluctuation in the composition of the gaseous state of the soil is a consequence of the different intensity of the release of this gas by microorganisms and plant roots.

The living part of the soil consists of soil microorganisms (bacteria, fungi, actinomycetes, algae, etc.) and representatives of many groups of invertebrates – protozoa, worms, mollusks, insects and their larvae, penetrating the horizons of the soil of vertebrates, etc. The active role of living organisms in the formation of soils determines its belonging to the biocosmic natural bodies – the most important components of the biosphere. They live mainly in the upper layer of the soil, near the root system of plants or directly on it, where the inhabitants get their food.

Saprophytes play an important role in the decomposition of decomposers. As a result, an amorphous mass is formed – humus – of dark brown or black color, which accounts for 1-20% of the soil. Humus – from the Latin word "earth" (soil) – is humus, a collection of dark-colored organic substances of the soil; the main organic substance of the soil containing nutrients necessary for higher plants. Humus is formed from the remains of plants and animals as a result of complex biochemical transformations depending on the heat capacity of the soil, moisture and aeration.

On Earth, **five typological groups of soils** occupy a leading position in terms of prevalence:

- soils of humid tropics and subtropics, mainly red earth and yellow earth, characterized by rich mineral composition and high mobility of organic matter;
- fertile soils of savannas and steppes - chernozems, chestnut and brown soils with a strong humus layer;
- poor and extremely unstable soils of deserts and semi-deserts belonging to different climatic zones;
- relatively poor soils of temperate forests - podzolic, brown and gray forest soils;
- permafrost soils, usually low-power, podzolic, gley, depleted of mineral salts with a poorly developed humus layer.

Examples of situational professionally oriented tasks for practical training

Task 1. Study the agrocenosis of a wheat field and divide the inhabitants into 3 groups (producers, consultants, reducers).

Task: to make 3 food chains characteristic of this agroecosystem.

The vegetation of the wheat field is made up, in addition to the wheat itself, also various weeds: white mar, field bodyak, yellow clover, field bindweed, creeping wheatgrass. In addition to voles and other rodents, there are grain-eating and predatory birds, foxes, wagtails, earthworms, ground beetles, bug harmful turtle, aphids, insect larvae, ladybug, rider. The soil is inhabited by earthworms, beetles, bacteria and fungi that decompose and mineralize straw and wheat roots left after harvesting.

Task 2. Conduct a comparative analysis of the ecological characteristics of any natural ecosystem and agroecosystem located in the Volgograd region. Make a conclusion about what their similarities are, and by what environmental criteria they differ.