Soil organic matter

Lecture № 3

Subject: "**Origin, composition, properties and agronomic value of the organic part of the soil. ”**

Plan

Introduction.

1. Sources of humus in the soil.
2. Conversion of organic matter in the soil and the process of humus formation.
3. Factors influencing the process of humus formation. Conclusions.

Introduction

An integral part of any soil is organic matter, ie a set of living biomass and organic remains of plants, animals, microorganisms, products of their metabolism and specific newly formed dark-colored humic substances that evenly permeate the soil profile (Fig. 9.1). The complex complex of soil organic compounds is due to the different composition of organic residues entering the soil, the different direction of the microbiological process, different hydrothermal conditions and so on. The organic matter of the soil contains all the chemical components of plants, bacterial and fungal plasma, as well as the products of their further interaction and transformation. These are thousands of compounds, the average lifetime of which in the soil can vary from a day to thousands of years.

1. Sources of humus in the soil

The source of humus is the organic remains of higher plants, microorganisms and

animals that live in the soil. Remains of green plants enter the soil in the form of terrestrial precipitation and dead root system of plants. The amount of organic matter entering the soil varies and depends on the soil-vegetation zone, composition, age and density of plantings, as well as the degree of development of grass cover.

The most significant source of soil organic matter is vegetation, which mobilizes and accumulates in edaphotopes the stock of potential energy and biophilic elements in the aboveground and underground organs of plants, in their remains.

Vegetation productivity in different ecosystems varies: from 1-2 t/ha per year of dry matter in the tundra to 30-35 t/ha - in tropical rainforests. Under herbaceous vegetation, the main source of humus are roots, the mass of which in a meter layer of soil is 8-28 t / ha (Steppe). Herbaceous vegetation in the area of coniferous and mixed forests (Polissya) on dry meadows accumulates 6-13 tons of roots per hectare in a meter layer of soil, under perennial sown grasses - 6-15 t/ha; annual cultivated vegetation - 3.1-15 t/ha of organic residues. Under forest vegetation, plant precipitation forms litter; the participation of roots in humus formation is insignificant. According to the profile, the content of root residues decreases with depth. These residues are often used by soil fauna and microorganisms, resulting in the transformation of organic matter into secondary forms.

Chemical composition of organic residues very diverse: water (70-90%), proteins,
lipids, lignin, resins, waxes, tannins. The vast majority of these compounds are macromolecular (mol. Mass 104-106). Wood decomposes slowly because it contains many resins and tannins, which are transformed only by specific microflora. Instead, legumes enriched with protein and carbohydrates decompose very quickly. There are many ash elements in the grass, and few in the trees. Remains of cultivated plants and organic fertilizers are the source of humus formation in arable soils.

A significant role in humus formation belongs to the soil fauna, which is divided into four groups: micro-, meso-, macro-, megafauna. Moreover, mainly micro- and mesofauna take an active part in the processing of soil organic matter, thus contributing to humus formation.

The total biomass of microorganisms in a meter layer of soil is up to 10 t/ha (approximately 0.5-2.5% by weight of humus), their remains are about a third of plant remains. Algal biomass is 0.5-1 t/ha, and invertebrate biomass is 12.5-15 t/ha (most of this biomass is formed by worms).

The chemical composition of living organisms is as follows (in% to dry matter):

1) bacteria - ash 2-10, proteins 40-70, lipids and tannins 1-40%;

2) algae - ash 20-30, cellulose 5-10, hemicellulose 50-60, proteins 10-15, lipids and tannins 1-30%;

3) perennial grasses - ash 5-10, cellulose 25-40, hemicellulose 25-35, proteins 5-12, lignin 15-20, lipids and tannins 2-10%;

4) tree leaves - ash 3-8, cellulose 15-25, hemicellulose 10-20, proteins 4-10, lignin 20-30, lipids and tannins 5-15%.

The nature of humus formation and the quality of humus depend on the chemical composition of the sources.

2. Conversion of organic matter in the soil and the process of humus formation

Once in the soil, organic residues undergo various mechanical, biochemical and physicochemical transformations.

The first stage transformations are the decomposition of organic residues. It occurs with the help of soil fauna, flora, microorganisms. Organic residues thus lose their anatomical structure, complex organic compounds are transformed into simpler and more mobile, ie into intermediate products of decomposition. These processes are biocatalytic in nature, as they occur with the participation of enzymes.

The first phase decomposition of organic residues - their physical destruction, grinding.

Another phase - hydrolysis of organic matter: proteins, for example, are broken down into peptides, and then - into amino acids; carbohydrates such as cellulose, starch - monosaccharides; uronic acids, fats - glycerin and fatty acids; lignin, resins,

tannins - for aromatic compounds.

Third decomposition phase - redox processes that use the enzyme oxyreductase to cause complete mineralization of organic matter:

deamination of amino acids, decarboxylation of organic acids, etc.

Reactions are very diverse, their nature is determined by the conditions, the composition of organic material. In aerobic conditions there is oxidation, in anaerobic - reduction. In the final form, amino acids are mineralized to CO2, H2O, nitrogen oxides under aerobic conditions, and carbohydrates are mineralized to anaerobic ones. Carbohydrates, adding oxygen, are converted first into organic acids, aldehydes, alcohols, then - in CO2 and H2O, and in the absence of oxygen they are fermented and form methane, alcohol, low molecular weight organic acids. Similar conversions to minerals occur with other intermediate decomposition products. Sugar and starch mineralize very quickly, proteins and cellulose are worse, lignin, resins and wax are poorly.

The rate of decomposition of organic residues decreases under anaerobic conditions until its complete cessation and the formation of peat. Most of the organic residues are oxidized to carbon dioxide and water.

And a smaller part undergoes the second stage of transformation - humification, ie the synthesis of humic substances. The level of humification of organic residues depends on the hydrothermal regime, botanical and biochemical composition of the residues, their number.

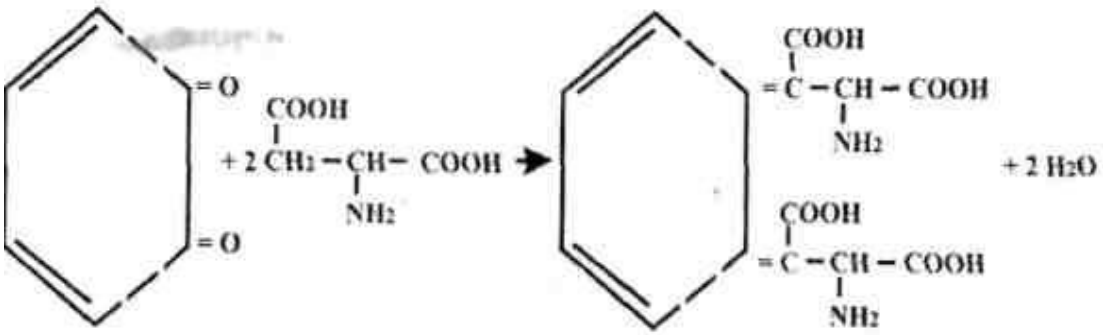
The nature of the formation of humic substances has interested researchers throughout the period of development of soil science. During this time, several hypotheses about the origin of humus have been put forward. A significant contribution to the study of humification processes was made by VR Williams, L.M. Alexandrova, IV Tyurin, MM Kononova, DS Orlov, MI Laktionov and others.

Today, the most common are the two concepts of humus formation.

Condensing (polymerization) -developed by MM Kononova, V. Fleig. The founders of the theory claim that humic substances are a product of condensation of structural fragments formed as a result of primary decomposition of organic

compounds of cyclic nature (lignin, tannins, resins, etc.). Simultaneously, polymerization occurs by oxidation of cyclic compounds by enzymes such as phenoloxidases through semihinones to quinones and the interaction of the latter with amino acids and peptides. According to MI Laktionov (1978), the question of participation in the condensation of larger fragments of lignin and the subsequent maturation of humic acids as not only an abiotic process remains debatable.

Formation of HA molecule during biocatalytic condensation of quinones with amino acids according to MI Laction occurs as follows:



This approach explains the structure of the micelles of humic compounds as colloidal surfactants: the hydrophobic nucleus of the organic colloid is represented by the aggregate of the phenolic part of the molecule, and the outer hydrophilic part - the amino acid (peptide) part of macromolecules. The predominant ionic groups on the surface of such molecules will be - COOH - NH2.

The concept of biochemical oxidation developed by LMAleksandrova. According to her definition, humification is a complex biophysico-chemical process of transformation of intermediate high-molecular decomposition products of organic residues into a special class of organic compounds - humic acids. Slow biochemical oxidation reactions, which result in the formation of a system of high molecular weight organic acids, are of paramount importance in the process of humification. Humification is a long process, as a result of which gradual aromatization of humic acid molecules takes place not due to condensation, but by partial cleavage of the least stable part of the macromolecule of newly formed humic acid. The system of humic acids then reacts with the ash elements of plant residues and the mineral part of the soil. The single system is gradually broken down into several fractions by molecular

weight, details of the structure of the molecule, the degree of solubility. Thus, in a very general form, the transformation of organic residues in the soil can be represented by the following scheme (Fig. 9.2).

3. Factors influencing the process of humus formation

It is established that the speed and direction of humification depend on many factors. The main ones are the amount and chemical composition of plant residues, water and air regimes, the composition of soil microorganisms, the reaction of the soil solution, the particle size distribution of the soil and so on. A certain ratio of these factors and their interaction determine a certain type of humification of organic residues: fulvate, humate-fulvate, fulvate-humate and humate.

Water-air regime of the soil affects humification as follows:

1) in aerobic conditions the following options are possible:

a) with sufficient moisture, temperature 25-30 ° C decomposition and mineralization are intense, so little humus accumulates;

b) in the absence of moisture little organic matter is formed in general, its decomposition and mineralization are slowed down, little humus is formed;

2) in anaerobic conditions with a constant excess of water and lack of oxygen slows down the decomposition of organic residues, as a result of anaerobic microorganisms methane, hydrogen, which inhibits microbiological activity, humus production is very weak, organic residues are preserved in the form of peat (swamp soils);

3) alternation of optimal hydrothermal conditions with some periodic drying of the soil - the most favorable option for humus formation, there is a gradual decomposition of organic residues, sufficient energy humification, consolidation of humus in dry periods (chernozems).

The nature of vegetation is a powerful factor influencing humus formation. As herbaceous vegetation dies annually, it produces the most vegetation, mainly directly in the soil in the form of root residues, which helps to quickly combine their decomposition products with the mineral part and protect against excessive

mineralization - the humus content in the soil increases. The chemical composition of herbaceous vegetation, rich in proteins, carbohydrates, calcium, promotes its rapid decomposition, the formation of soft humus - its most valuable type. Woody vegetation, enriched with wax, resins, tannins, which are bad

decompose mainly by fungal microflora, contributes to the accumulation of very acidic products of decomposition of residues, the processes are mainly in the forest floor, humus is formed coarse, accumulates in the upper low-power horizon.

In addition, humus formation, its direction is influenced by the number and composition of microorganisms, physical properties, grain composition and chemical composition of the soil. The best conditions are created in soils rich in Ca, which have a close to neutral reaction environment, the average content of microorganisms, average particle size distribution, good structure.

Conclusions

Humic substances are decomposed (mineralized) by special microorganisms, especially in the presence of organic substances that have not yet been humified. However, it should be noted that the decomposition of humus is a long process and requires the participation of a large group of microorganisms. The stability of humic acids is related to the spherical shape of molecules consisting of many heterogeneous units that are irregularly connected by covalent bonds. The most intense is the mineralization of fulvic acids. The maximum rate of mineralization is observed at optimum humidity and temperature for microorganisms, decreases with excessive moisture in heavy soils. Particularly sharp decrease in humus content in the soil is observed with the use of high doses of nitrogen fertilizers. This is due to the activation of soil microorganisms, which include in their metabolic cycles the organic matter of the soil. The ability to decompose humus is inherent in many microorganisms, but the leading role belongs to fungi and actinomycetes (in particular, nocardia). In the process of decomposition of humic substances, a large number of plant nutrients are released, especially nitrogen.