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INFLUENCE OF NITROGEN FERTILIZERS ON THE BIOLOGICAL ACTIVITY OF THE SOIL OF THE RAPESEED ROOT ZONE

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Abstract. *Soil microbiocenosis is a dynamic, well-balanced system with a complex spatial and trophic organization. The main biosphere function of soil microbiocenosis is the destruction of organic matter. The polyfunctionality of microorganisms in the rhizosphere gives them the opportunity to participate in opposite biochemical reactions of the soil, which underlie the preservation of metabolic equilibrium in nature. Agrotechnological methods of growing rapeseed require high doses of mineral fertilizers, especially nitrogen fertilizers. The use of high doses of nitrogen mineral fertilizers leads to changes in the balance of the chains in the ecosystem, including microbiological activity. It is microbiological activity that is the reactionary force that quickly reacts to external factors.* ***Method****: In our work, a study of the biological activity of the soil of the root zone of rapeseed for the action of nitrogen fertilizers is presented. The study was carried out in the soil of temporary field experiments on agrocenosis of winter rapeseed, variety Black Velikan. The conditions of the experiment assumed the introduction of nitrogen fertilizers – 120, 150 and 180 kg/ha. The control option did not include fertilization. Determination of the biological activity of the soil in the root zone of rapeseed plants included the determination of the microbial biomass of carbon, the intensity of carbon dioxide emission, antifungal and cellulolytic activity, and the phytotoxicity of the soil.* ***Results:*** *The study of the soil of the root zone of rapeseed plants showed a directly proportional relationship between the dose of nitrogen fertilizer applied and biological activity. It was revealed that the fungistatic status of the soil of the root zone of rapeseed plants under the condition of applying nitrogen fertilizers in comparison with the control grew by 2.3–5.5 times; cellulosic activity by 1.5, the intensity of carbon dioxide emission increased by 2.1–3.6 times.* ***Conclusions****: The content of microbial biomass was recorded at a high level; studies have shown that the content did not depend on the amount of fertilizers applied. Thus, the indicators of the biological activity of the soil of the root zone of rapeseed plants in the flowering phase indicate that the physiological and metabolic activity of microbial communities is at a high level and depends on exogenous sources of nitrogen.*

Keywords*: biomass, carbon dioxide emission, phytotoxicity, antifungal soil activity, cellulolytic activity, nitrogen fertilizers, rapeseed*

INTRODUCTION

Microbial communities of the soil are represented by a set of organisms interacting between themselves, which populate an ecological niche with homogeneous conditions and transform the energy and organomineral substances of this ecosystem. All connections in the community between members of associations of microorganisms are built on trophic interactions [1]. Most soil

microorganisms, with the exception of oligotrophs, remain inactive until an exogenous organic substrate is supplied [2].
The active role of the root system in most metabolic and synthetic processes, as a result of which complex substances are formed from the absorbed ions and assimilants of leaves, which are important not only for plants, but also for the soil microflora in contact with the root [3]. Plants cause not only changes in the structure of the microbial community of the rhizosphere, but also form special physicochemical conditions of the soil in the root zone. In turn, the properties of the rhizosphere environment can influence both directly and indirectly on the course of microbiological processes in it [4].
In agro-ecosystems, the cycle and nitrogen conversion cycle is characterized by a complex of interrelated biological, biochemical and chemical processes. A functional feature of nitrogen transformation in soil is their cyclicity. Therefore, the processes of mineralization are always accompanied by the processes of immobilization [5] and constantly occur in the soil. The most complete description of the interrelations of the processes of mineralization and immobilization was proposed by Janson [6] in the theory of a constantly operating intrasoil nitrogen cycle.
According to the theory of the intrasoil nitrogen cycle, in the process of immobilization, the ammonium form of nitrogen is more actively assimilated by the soil microbiocenosis in comparison with the nitrate form [5–7]. Each ecological-trophic and taxonomic group of microorganisms takes part in the processes of nitrogen immobilization-mineralization, the degree of which is determined by ecological-soil conditions [7, 9, 10].
The use of high doses of nitrogen mineral fertilizers in agricultural production leads to changes that disrupt the balance of chains in the ecosystem, formed over a long period. The peculiarities of the transformation of compounds of biogenic elements, including nitrogen, in agrocenoses depend on a number of factors, which include the climatic conditions of the region and a particular season, the geochemical influence of soils, the type of vegetation, anthropogenic impact and microbiological activity, is the least studied.
The structure of microbial populations (spatial, taxonomic, and functional) mainly depends on the totality of relationships that develop within communities. The article presents a study of the effect of nitrogen fertilizers on the biological activity of the soil of the root zone of rapeseed plants during flowering.

MATERIALS AND METHODS

The studies were carried out in the soil of the root zone of winter rapeseed plants, Black Giant (originator Vinnitsa State Agricultural Experimental Station, Ukraine). The predecessor is black steam. The accounting area of the plots is 25m^2. The placement of variants in the experiment is systematic - sequential, repetition - fourfold. Experiment scheme: 1. Control (without fertilization) 2. $N_{120}P_{80}K_{140}$; 3. $N_{150}P_{80}K_{140}$; 4. $N_{180}P_{80}K_{140}$.
Soil – gray forest podzolic medium loam, humus content up to 2.06%, pH_{salt} 4.2, hydrological acidity 3.24 mg eq. per 100 g of soil, content of alkaline hydrolyzed nitrogen 74.2 mg/kg of soil (according to Cornfield), mobile phosphorus 174 mg/kg of soil and exchangeable potassium 115 mg/kg of soil (according to Kirsanov).
In autumn, the background of feeding rapeseed plants with nitrogen fertilizers was not carried out, since the excess of nitrogen ions in the soil solution reduces the frost resistance of plants [11]. The first feeding (for all experimental variants) of rapeseed plants with nitrogen fertilizers was carried out in the spring of next year, on frozen soil before vegetation. The second top dressing (for the 3rd and 4th variants of the experiment) was carried out two weeks after the resumption of the growing season before the beginning of the budding phase in the amount of 30 kg/ha. The third stage of feeding rapeseed plants was carried out only for the 4th variant, in the amount of 30 kg/ha, before flowering.
Soil samples of the rapeseed rhizosphere were taken in the 2nd decade of May (flowering phase), since it is believed that during the flowering of a plant, processes in the microbiocenosis are most active
The biomass of microorganisms in the soil of the root zone was determined by the rehydration method [12]. The intensity of carbon dioxide emission from the soil was determined by the Shtatnov absorption

method. The cellulose-destructive activity of the soil was determined by the Christensen method in the Zvyagentsev modification [13].
The phytotoxicity of the soil was determined by the Grodzinsky method in the Mochalov – Sherstoboev modification [14]. The antifungal activity of the soil was determined by decomposing soil samples of 0.5 g into wet disks of filter paper with a diameter of 2 cm, which were laid out in the center of a Petri dish for sowing on the lawn of test cultures of phytopathogenic fungus, which was grown on acidic Chapek medium for micromycetes, with the measurement of the transparent zone of no growth of the test culture around the paper after 5 days. [15]. Statistical processing of experimental results was performed with Statistica 6.0 program.

RESULTS AND DISCUSSION

Microbial groups as in the soil and also in the biocenosis cooperate with each other, creating extremely complicated complexes. Such groups use natural resources in their interactions, the functioning of which is ensured by a large number of trophic and energy connections between plants, animals, fungi and microorganisms. Biological activity of soil is a function of its living component, which demonstrated through the intensity of biological processes of the microbial group. In the process of vital activity, the soil microflora processes organic residues in the soil, and the microbial mass itself, the value of which is directly dependent on the content of organic matter, is an important source of nutrients available to plants.
In temporary field studies, it was found that the application of large amounts of mineral fertilizers, which are limiting factors in the formation of vegetative mass of rapeseed plants, high quality crops, caused some changes in the microbiocenosis of rapeseed rhizosphere. In agroecosystems studied the content of microbial biomass, carbon dioxide emissions, phytotoxicity, cellulose-destructive and antifungal activities under the application of nitrogen fertilizers (Table 1).
The obtained results indicate that an active increase in the content of microbial biomass was observed in the flowering phase (the most active phase of ontogeny of rapeseed plants) and its gradual decrease in accordance with the final phases of plant vegetation. As for the introduced nutrients, an increase in the microbial carbon content was observed for all three concentrations of nitrogen relative to control. But the difference between the options in determining this indicator was not significant. The intensity of carbon dioxide release is a very important integral indicator that determines the level of overall biological activity of the soil. The level of carbon dioxide emission intensity was directly proportional to the amount of nitrogen fertilizers applied. Thus, the difference in respiration intensity between variant $N_{180}R_{80}K_{140}$ and control variant was 30.4 mg of CO_2/kg of soil per day. Thus, the intensity of dioxide emissions was higher in the variants where nitrogen fertilizers were applied in the amount of 150 kg/ha and 180 kg/ha.

Table 1 Biological activity of the soil of the root zone of winter rapeseed plants (flowering phase)

Variant	Microbial biomass, μg C/g of soil	Intensity of CO_2 emission of soil, mg CO_2/kg of soil per day	Phytotoxicity of soil, %	Antifungal activity, mm	Cellulose-destructive activity, %
Control	174.4±11.2	11.5±1.6	6±1.1	1.88±0.08	27.6±1.1
$N_{120}P_{80}K_{140}$	201.7±14.8	24.3±1.1	10±1.1	4.32±0.15	26.4±1.5
$N_{150}P_{80}K_{140}$	209.6±20.1	35.7±2.4	12±1.2	6.28±0.31	24.7±1.8
$N_{180}P_{80}K_{140}$	198.6±14.3	41.9±3.7	13±1.2	10.42±0.42	39.3±2.6

The level of phytotoxicity of the soil of the root zone of rapeseed plants in the flowering phase was not high and ranged from 6 to 13%, which indicates a small number of phytopathogenic micromycetes in the root zone of plants at the beginning of the growing season.
The role in the formation of the fungistatic status of the soil belongs to the microbial group; in the conditions of the experiment the application of nitrogen fertilizers increased the antifungal activity of the soil. The fungistatic status of the rapeseed rhizosphere soil depended on the amount

of applied nitrogen, and the antifungal activity increased as the amount of applied fertilizers increased.
The antifungal activity of the rhizosphere soil of the variant where rapeseed plants were grown without adding additional food sources (control) in the physiologically most active phase of plant development was 2 times lower compared to the variant where nitrogen was applied in the amount of 120 kg/ha, and 5.5 times compared to the variant where nitrogen was applied in the amount of 180 kg/ha, the zone of suppression of the test culture was 2.1 mm for control and 11.4 mm – for the variant with the maximum amount of nitrogen applied.
According to the intensity of cellulose transformation, the soil of the root zone of rapeseed plants of the experimental agrocenoses was characterized by an average level of activity. In the flowering phase of rapeseed plants, the greatest development of cellulose-destructive microflora was noted in the variant $N_{180}P_{80}K_{140}$ – 36%.

CONCLUSIONS AND RECOMMENDATIONS

The results of the study of the biological activity of the soil of the root zone of rapeseed plants in agrocenoses show that there is a linear relationship between the studied indicators (biomass, carbon emissions, phytotoxicity, cellulose activity, antifungal activity) and the amount of nitrogen fertilizers.
It is shown that the fungistatic status of the soil of the rhizosphere of rapeseed plants with increasing the amount of applied nitrogen fertilizers increased by 2.3–5.5 times; cellulose-destructive activity of 1.5, the intensity of carbon dioxide emissions increased by 2.1–3.6 times.

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