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DECREASING ANTHROPOGENIC PRESSURE ON SOIL MICROFLORA BY USING CAPSULATED FERTILIZERS

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Abstract. This article focuses on finding ways to preserve soil fertility. At the present time, in conditions of intensive farming, do not pay attention to such an important part of the agricultural ecosystem as soil microflora. An impact on the number of total and nitrogen-fixing microorganisms of the soil at bringing different types of fertilizers on the most common types of soil of Lviv region are determined.

Key words: soil microflora, capsulated fertilizer.

Introduction

The land owners mostly consider soil resources as a source and a way to profit. The processes of intensification of modern agriculture led to significant environmental problems associated with soil degradation and depletion of the fertility. Soil is a living medium that develops by its own laws.

One of the most important factors of soil fertility is the activity of microorganisms. Thanks to their activity, nutrients accumulate in the soil (nitrogen, potassium, phosphorus and others.) in a form available to plants.

Soil microorganisms are a mandatory component of any agricultural ecosystem; they have a powerful enzymatic apparatus to perform a variety of functions in the circulation of substances, ensuring the continuing operation of agroecosystems in general [1]. Application of fertilizers is rapidly intensifying microbiological processes in the soil. It's up to certain limits can be regarded as a positive phenomenon if there is a task to increase productivity [2].

However, the pursuit for maximum productivity, uncontrolled use of chemical fertilizers with the violation of the rules of agricultural techniques leads to soil saturation with these drugs, and through them – to the pollution of water and air basins, changes in the chemical composition of plant products and obtaining food harmful to human health. Particular attention should be paid to nitrogen fertilizer as the most dangerous for the whole ecosystem [3]. First, it's negative effect on the microorganisms involved in the transformation of nitrogen in the biosphere and the process of nitrogen fixation, ammonification, nitrification, denitrification. Increasing the dose of fertilizer reduces the number of soil microorganisms and it's biomass, has negative impact on microorganisms, most of which die [4].

In response to the changes in the conditions of life in soil microbial coenosis the natural balance is disturbed between the various ecological and trophic groupings responsible for basic biological processes: nitrogen fixation, nitrification, decomposition of cellulose, humification and others. Also, the activity of enzymes associated with these processes decreases [5].

It is known that fertilizer as a source of nourishment, especially in soils with high organic matter content, stimulate microbial activity [6]. Under the influence of the fertilizer plants develop better and their root exudates intensify the development of microflora. However, this activation under conditions of excess of mineral nutrients in the soil, insufficiently secured with sources of carbon compounds leads to negative consequences. Under these conditions the microflora contributes to the intensification of some undesirable processes, including the increase in the mineralization of humus which consequently worsens the structure, reduces fertility and using organic compounds of root tissues can inhibit plant growth [7].

We investigated the dependence of the soil microflora changes under the influence of granular and capsulated fertilizer to test the hypothesis that fertilizers do not have harmful effect on the soil microflora.

Materials and methods

Two complexes of studieswere performed. In the first series of studies of the effect of fertilizers on microorganisms we have isolated the weather factors in the system "soil – fertilizer" ("S+F"). To accomplish this, 3 types of the most common soil in Lviv region were selected: dark-gray podzolic, light-gray podzolic and sod-podzolic.

Four types of fertilizers were applied in terms of 1000 kg/ha in each type of the soil. Samples were kept in a boxing with constant temperature of 21 °C and relative humidity of air of 90 % (Fig. 1).

Fig. 1. Storage of samples in the system "soil – fertilizer" (t = 21 ° C, air humidity – 90 %)

Soil moisture was maintained at the level on the day of sampling, which amounted to dark-gray podzolicsoils – 27.2 %, light-gray podzolic – 27.6 %, sod-podzolic – 22.8 %.

To fulfill the second series of studies, we studied the effect of fertilizers on microorganisms in the system "soil – fertilizer – plant" ("S+F+P"). In the studies we reproduced the modes of loosening and watering plants, that are practiced in greenhouse conditions [8]. The temperature regime was at the level of 15–18 °C. Dark-gray podzolic soil in pots was selected for this experiment, for application of 4 types of fertilizers in terms of 1000 kg/ha and seeds of watercress.

The scheme of the experiment for each soil type provided application of different types of fertilizers and included five options:

1. control (without fertilizer);
2. granulated fertilizer (GF) (Nitroamophoska, N:P:K = 16:16:16);
3. capsulated fertilizer No. 1 (CF No. 1) (10 % capsule, composition: polystyrene-lignin);
4. capsulated fertilizer No. 2 (CF No. 2) (10 % capsule, composition: polystyrene-lignin-zeolite);
5. capsulated fertilizer No. 3 (CF No. 3) (10 % capsule, composition: lignin-zeolite).

Capsulation of granular fertilizers was carried out in the machine with a boiling layer of periodic action cylindrical-conical-type with a guiding cylinder.

To determine the number of microorganisms in the soil the method of planting soil suspensions on agar nutrient medium was used. The nutrient agar was applied to determine the total number of microorganisms, and Ashby agar medium for nitrogen-fixing microflora.

Results

The results obtained in the "soil – fertilizer" system, shown in Fig. 2, Fig. 3 and Table 1, indicate a positive impact of fertilizers on soil microbiological activity.

In light-gray podzolic soil in the "soil – fertilizer" system, simple granular fertilizer causes a sharp fluctuations in the change of the number of microorganisms – from 6×10^9 to 2×10^7 CFU (colony-forming unit) / 1g of soil within 30 days. Capsulated fertilizer No. 2, which stably released nutrients and did not cause sharp changes in the number of microorganisms, appeared to be the best under the given conditions. In addition, on the 90-th day of this variant the greatest number of microorganisms –2×10^7 CFU/1g of soil was found (Fig. 2).

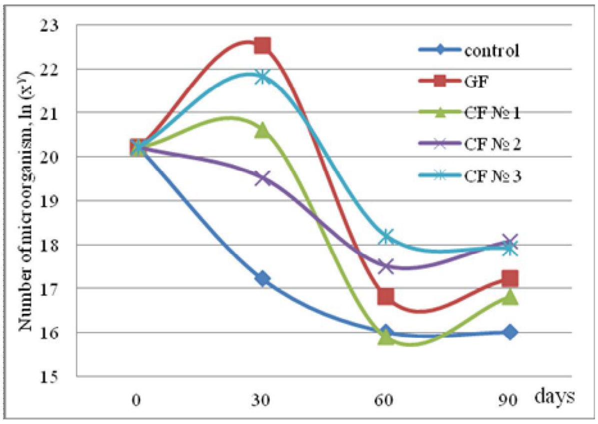

Fig. 2. The logarithmic dependence of the total number of microflora light-gray podzolicsoil in the "soil – fertilizer" system.

In light-gray podzolic soil in the "soil – fertilizer" system at an early stage within 30 days the number of nitrogen-fixing microflora considerably increased in all variants. However, during the 90 days, variants of capsulated fertilizer № 3 and № 2 were the best, where the greatest quantity of microorganisms was revealed – 9×10^6 and 8×10^6 CFU / 1 g of soil, respectively. In comparison at this phase of research, in the variant with granular fertilizer, the number of microorganisms was 4×10^6 CFU/1 g of soil, compared to 3×10^6 CFU/1 g of soil at the control (Fig. 3).

The studies were carried out on three types of soil in the “soil – fertilizer” system (Table. 1). In all the studied variants of the fertilizer by 30-th day of the experiment it was revealed that the total number of microorganisms was higher and amounted to $3\times10^8 – 2\times10^{10}$, and $2\times10^7 – 3\times10^7$ CFU / 1 g of soil at the control.

On the 90-th day of studies it was found that the total number of microorganisms in variants with capsulated fertilizer on all types of soil was 9×10^6 – 2×10^8 and it was several times higher than at the control – 7×10^6– 9×10^6 CFU / 1 g of soil.

A number of nitrogen-fixing microorganisms almost did not change during the experiment. For example, the amount of nitrogen fixers on the 90-th day of the study in versions with capsulated fertilizer was 4×10^6 - 9×10^6 CFU / 1 g of soil and at the control it was $3\times10^6 – 8\times10^6$ CFU / 1 g of soil.

Results of the study, conducted in the “soil – fertilizer – plant” system, are shown in Fig. 4 and Fig. 5. The obtained results indicate that at the initial stage of the investigation the total number of soil microflora decreased in all the variants, only in the version with capsulated fertilizer No. 3 its number increased from 3×10^8 to 7×10^8CFU / 1 g of soil.

Table 1

Change in the number of microorganisms in the system “soil – fertilizer"

Soil	Days / Variant	Total of microflora, CFU / 1 g of soil				Nitrogen-fixing microflora, CFU / 1 g of soil			
		0	30	60	90	0	30	60	90
Dark-gray podzolic	Control	4×10^8	4×10^7	8×10^6	7×10^6	3×10^5	5×10^6	9×10^6	7×10^6
	GF		9×10^9	3×10^7	5×10^7		9×10^6	9×10^6	7×10^6
	CF № 1		5×10^9	9×10^6	4×10^7		4×10^6	7×10^6	4×10^6
	CF № 2		6×10^9	2×10^7	3×10^7		6×10^6	6×10^6	9×10^6
	CF № 3		9×10^9	9×10^6	9×10^6		7×10^6	9×10^6	8×10^6
Light-gray podzolic	Control	6×10^8	3×10^7	9×10^6	9×10^6	8×10^5	9×10^6	4×10^6	3×10^6
	GF		6×10^9	2×10^7	3×10^7		9×10^6	7×10^6	4×10^6
	CF № 1		9×10^8	8×10^6	2×10^7		8×10^6	5×10^6	6×10^6
	CF № 2		3×10^8	4×10^7	7×10^7		8×10^6	8×10^6	8×10^6
	CF № 3		3×10^9	8×10^7	6×10^7		9×10^6	7×10^6	9×10^6
Sod-podzolic	Control	2×10^{10}	2×10^7	6×10^6	8×10^6	7×10^5	9×10^6	9×10^6	8×10^6
	GF		8×10^9	4×10^7	5×10^7		7×10^6	3×10^6	3×10^6
	CF № 1		6×10^8	4×10^6	7×10^7		7×10^6	5×10^6	7×10^6
	CF № 2		7×10^8	2×10^7	2×10^8		8×10^6	8×10^6	6×10^6
	CF № 3		2×10^{10}	4×10^7	7×10^7		9×10^6	4×10^6	8×10^6

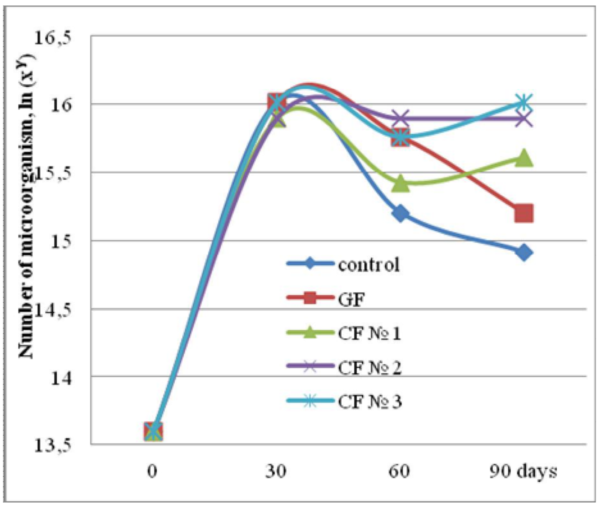

Fig. 3. The logarithmic dependence of the number of nitrogen-fixing microflora of light-gray podzolic soil in the system “soil – fertilizer”

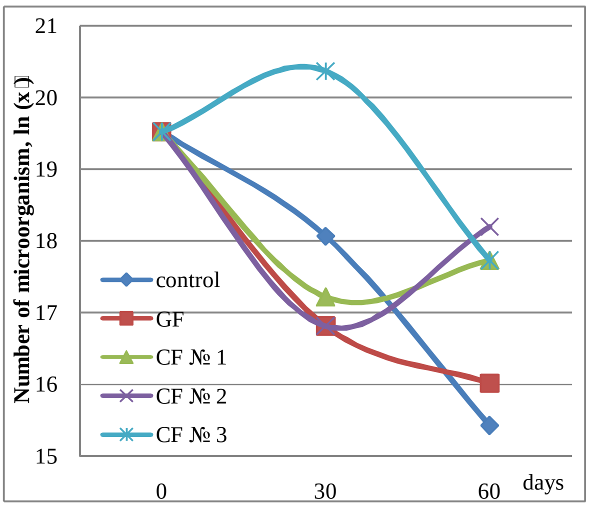

Fig. 4. The logarithmic dependence of the total soil microflora change in the “soil – fertilizer – plant” system

On the 60-th day of the experiment the total number of microflora in the soil at the control and in the variant with granular fertilizer decreased to 5×10^6 and 9×10^6 CFU / 1 g of soil. In the variants with capsulated fertilizer No. 1 and No. 2 it increased and amounted to 8×10^7 and 5×10^7 CFU / 1 g of soil, respectively (Fig. 4). In the variant with capsulated fertilizer No. 3 the total number of soil microflora decreased to 5×10^7 CFU / 1 g of soil.

Thus, in this experiment the best variant was in the use of capsulated fertilizer No. 2, which provided the greatest increase in the total soil microflora in the "soil – fertilizer – plant" system.

Our research has found that the number of nitrogen-fixing soil microorganisms in the system "soil – fertilizer – plant" in all variants was almost at the same level, except of the variant with capsulated fertilizer No. 3 (Fig. 5). There was much more nitrogen-fixing microflora compared to control and other variants.

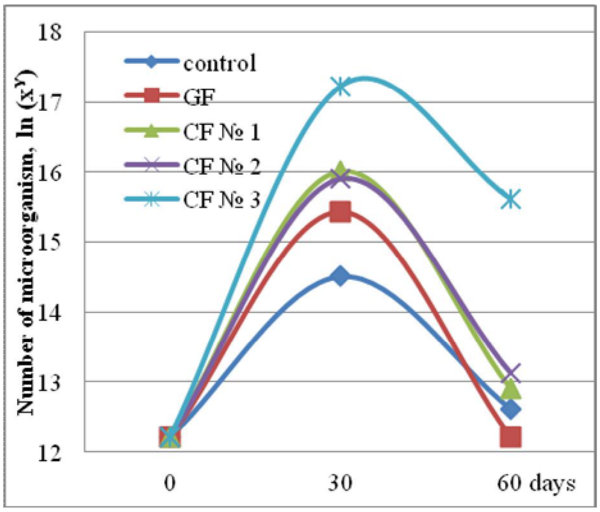

Fig. 5. The logarithmic dependence of the number of nitrogen-fixing soil microorganisms change in the "soil – fertilizer – plant" system.

The capsulated fertilizer No. 3 after 30 days of exposition manifested both high effect of the total number of microorganisms and nitrogen-fixing microorganisms. This is possible due to the fact that the composition of the capsule shell includes 45 % of hydrolytic lignin, which is common natural compound and activates the growth of microorganisms. Results in variants with other fertilizers were close to control.

After 60 days, the total number of microflora in all the variants of application of capsulated fertilizer was higher than at the control.

Only in the variant with capsulated fertilizer No. 3 the number of nitrogen-fixing microflora was higher if compared to the control. In other variants of the experiment the deviation was negligible compared to the control.

The pattern of change in the total number of microflora from using capsulated fertilizer No. 2 in variants is shown in Fig. 6. At the beginning of the exposure it decreased, but later significantly increased compared to the options with simple granular fertilizer in which the total number of soil microflora decreased within the duration of the experiment.

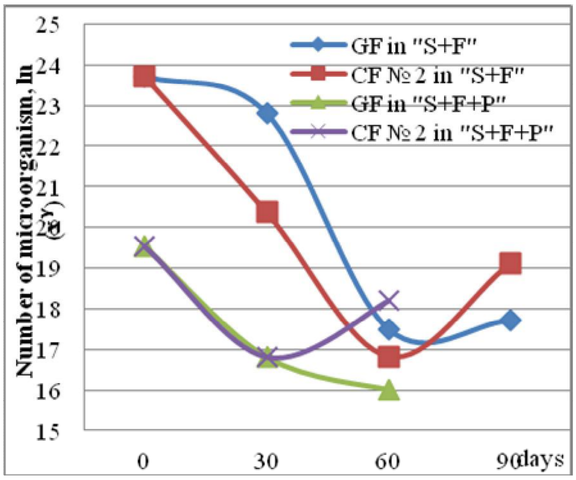

Fig. 6. The logarithmic dependence of the total soil microflora change in the two systems.

It was found that variants with capsulated fertilizer No. 3 have more favorable impact on the number of nitrogen-fixing soil microflora in two experimental systems compared to simple granular fertilizer (Fig. 7).

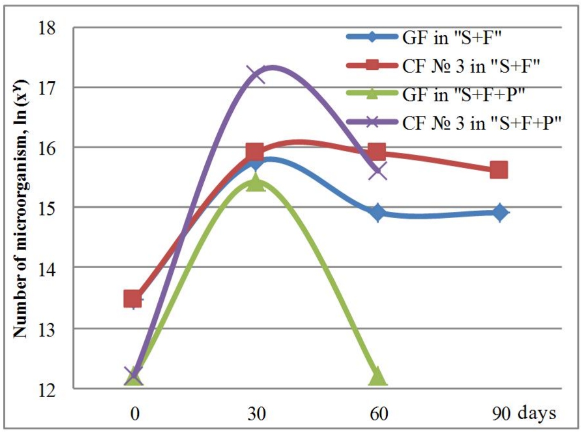

Fig. 7. The logarithmic dependence of the number of nitrogen-fixing soil microflora change in the two systems.

Conclusion

Thus, the increased application rate of capsulated fertilizer, which was 1000 kg/ha, did not harm the general and nitrogen-fixing soil microflora and positively affected the number of microorganisms in separate variants. In particular, in the variant with capsulated fertilizer No. 2, in which the greater impact on the change of the total quntity of soil microflora in two studied systems was found. In the two systems of the research the best conditions for the development of nitrogen-fixing soil microflora were established in the variant with capsulated fertilizer No. 3.

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