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# Microbiological Buffering of Different Types of Soils of the Lipetsk Region to the Effects of Roundup Herbicide

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## Annotation

The buffering of soils to foreign chemical invasion lies not only in the size of the cation exchange capacity or the amount of organic matter, but also in the number and structure of the microbial community. The object of research was 5 types of soils of the Yelets district of the Lipetsk region in the rhizosphere of the apple tree. Spraying of the soil surface with a Roundup herbicide solution was carried out with a manual knapsack sprayer. The concentration of the active substance (glyphosate) is 2.0%. The rate of consumption of the working solution is 696.6 l / ha. 3 days after spraying the soil surface with Roundup herbicide at a concentration of D.V. (glyphosate) 2.0 % at a working solution consumption of 696.6 l/ha in a model experiment with clone rootstocks of apple trees, an inhibitory effect on the soil microflora in the rhizosphere of apple trees has already been observed. Depending on the type of soil, the decrease in the number of bacteria was 1.3-1.9 times, soil fungi – 1.2-2.6 times. Soil yeasts proved to be more resistant to Roundup herbicide than bacteria and fungi. The bacteria were more resistant than the fungi. As a result, the total number of microorganisms significantly decreased only on floodplain granular soil. The most resistant bacterial complex to the action of Roundup herbicide turned out to be a complex of leached chernozem and sod-podzolic soil. The most resistant mushroom complex to herbicidal load turned out to be a complex of forest soils (sod-podzolic and dark gray forest). In second place in this indicator is a very buffer soil – leached chernozem. And the most unstable fungal complexes to this effect were complexes of floodplain soils (granular and layered). Despite the less favorable agrochemical properties of forest soils (dark gray forest and sod-podzolic) compared to leached chernozem, their buffering to the bactericidal and fungicidal action of the herbicide turned out to be the same high.

## Introduction

Traditionally, it is considered that soil buffering is a linear relationship between pH and the amount of added acid or alkali [24]. According to other approaches, soil buffering is a property that determines the ratio between the solid phase of phosphorus and its concentration in solution [16]. Another definition of soil buffering is its ability to restore its previous parameters after chemical intervention. Consequently, there will be such terms as, for example, zinc buffering, etc [17]. The commonly accepted components of soil buffering are cation exchange capacity, calcium ions, aluminum, soil oxides, earthworm coprolites, physical clay and organic carbon [10,13,21,23,25,26,30]. Soil buffering can decrease for various reasons, for example, due to soil oversaturation with nitrogen, decomposition of clay minerals, excessive soil contamination with herbicides. Soil buffering depends on the type of soil, vegetation, climate, land use, scale and mode of preliminary technogenic intervention [11,27,29]. In turn, the buffering of the soil affects the composition of groundwater [22]. A significant reserve for increasing soil buffering in apple plantations is the blackening of the soil with perennial grasses, since this anti-erosion technique preserves nutrients and increases the biological activity of the soil [12]. The soil of the rhizosphere of the apple tree contains more soil fungi than outside it. This is a very favorable factor for the longevity of apple orchards. With the age of the garden, the number of soil fungi in the rhizosphere of the apple tree increases [31]. The introduction of nitrogen into the soil and its acidification increases the proportion of fungi relative to bacteria [19].

The effect of pesticides on the soil microflora is different. Some herbicides increase the number of fungi and actinomycetes, others restrain their growth for 7-10 days [28]. Thus, the pesticide carbofuran stimulated the population of azospirillus and other anaerobic nitrogen fixers, the herbicide butachlor, on the contrary, reduced, diuron and chlortholuron did not show a difference between treated and untreated soil, the phosphorus-containing herbicide glyphosate and the insecticide metamidophos stimulated the growth of soil microorganisms, and the insecticide fenamiphos was detrimental to nitrifying bacteria [20]. It was found that the introduction of herbicides such as 2,4-D, butachlor, pretilachlor and pyrazosulfuron ethyl reduces the number of heterotrophic bacteria, fungi and actinomycetes in the soil, but after a month the soil restores the pool of these microorganisms [18]. The introduction of the herbicide atrazine led to the complete death of bacteria such as Pseudomonas sp. and Bacillus sp., but showed the resistance of fungi such as Aspergillus niger, A. alavus, Penicillium sp. and Trichoderma sp. [9]. The introduction of the herbicide 2,4 D, butachlor and rifite led to a reduction in the number of bacteria after a day and this effect lasted from 15 to 45 days. Fungi and actinomycetes suffered to a lesser extent [15]. The introduction of the herbicide simazine did not affect the number of fungi, and the double introduction of paraquat reduced their number to a greater extent than other microorganisms [14].

Despite the herbicidal load, the trunk strips of old apple orchards contain more soil fungi than in the row spacing soil. There are more soil fungi in podzolized chernozems and gray forest soils than in soils uneducated under the forest, for example, in leached chernozems [31]. There is insufficient information in the scientific literature about the resistance of soil microbiocenosis to herbicides, depending on its type and subtype. The purpose of this work is to compare the bacterial and fungal resistance of different types of soil in the Lipetsk region to the introduction of Roundup herbicide.

## Objects and Methods of Research

The research was conducted in 2016-2023 on the basis of the Agro-Industrial Institute of the I.A. Bunin Yelets State University. The object of research was 5 types of soils of the Yelets district of the Lipetsk region in the rhizosphere of the apple tree. To do this, the model experience with the three most common apple rootstocks in production: (62-396, 54-118 and PB-9) was laid in the spring of 2016. The soils were selected from the humus horizons of 5 predominant soils of the Lipetsk region located under the deposit. The mass of soil in one vessel is 4 kg. 1 rootstock was planted in each vessel. The repetition of the experience is 5-fold. The arrangement of plots is 3-tiered sequential. The scheme of planting rootstocks 75 x 20 cm. Spraying of the soil surface with a Roundup herbicide solution was carried out on June 29 with a hand-held knapsack sprayer. The concentration of the active substance (glyphosate) is 2.0%. The rate of consumption of the working solution is 69.66 ml/m2 (696.6 l/ha). Soil sampling for microbiological analyses was carried out 3 days after spraying. Soil sampling was carried out according to the methodological instructions of V.V. Tserling and L.A. Egorova [5]. The number of mesophilic aerobic and facultative anaerobic microorganisms (NMAFAM), yeast and bacteria in the soil was determined by sowing on nutrient agar, fungi - on Chapek medium [6]. Agrochemical analyses of the soil were carried out according to the instructions of the Central Information Scientific and Analytical Association [4]: the content of humus according to the method of I.V. Tyurin modified by V.N. Simakov [1], mobile phosphorus and exchangeable potassium - according to the method of F.V. Chirikov [7] on the photometer KFK-2 and flame photometer FPA-2, pH water extraction – by the ionometric method on the EV-74 ionomer [1]. the total nitrogen content – by wet salting [8], the content of exchangeable calcium and magnesium – by the trilometric method [1]. Soil assessment was carried out according to the textbook by V.D. Ivanov and E.V. Kuznetsova [3]. Mathematical data processing was carried out by analysis of variance [2].

## Research Results

According to the agrochemical data obtained by us, forest soils (dark gray and sod-podzolic) were characterized by a slightly acidic reaction of the medium, the remaining soils were neutral (Table 1).

**Table 1:** Agrochemical Properties of Soils of the Model Experiment with Apple Rootstocks in 2017-2022.

| Humus, % | $pH_{H2O}$ | Total nitrogen, % | Mobile phosphorus | Exchange potassium | Exchange calcium and magnesium |
|---|---|---|---|---|---|
| | | | mg / 100 g | | mg-equivalents / 100 g |
| **Leached chernozem** | | | | | |
| 5,8 | 7,0 | 3,0 | 25,3 | 13,1 | 9,7 |
| Dark gray forest soil | | | | | |
| 3,5 | 5,2 | 2,1 | 6,7 | 7,2 | 7,2 |
| **Floodplain granular soil** | | | | | |
| 6,2 | 7,6 | 3,0 | 19,1 | 11,4 | 2,9 |
| Floodplain layered soil | | | | | |
| 6,1 | 7,6 | 3,0 | 19,2 | 11,1 | 3,0 |
| **Sod-podzolic soil** | | | | | |
| 3,4 | 5,1 | 1,7 | 7,3 | 6,0 | 3,6 |
| $NSR_{05}$ | 1,1 | 0,5 | 3,2 | 2,0 | 0,6 |
| Accuracy of experience, % | 5,0 | 4,3 | 6,1 | 5,6 | 4,5 |

According to the content of mobile phosphorus, leached chernozem had a very high security, high – floodplain granular and layered, medium – dark gray forest and sod-podzolic soil. According to the content of exchangeable potassium, leached chernozem showed high availability, floodplain soils showed increased availability, and forest soils showed medium availability. The humus content in leached chernozem and both floodplain soils was at an average level, in forest soils – at a low level.

The total nitrogen content in the sod-podzolic soil was very low, in all other soils – low. The content of exchangeable calcium and magnesium was highest in leached chernozem, slightly less in dark gray forest and the lowest in all other soils. Thus, leached chernozem according to agrochemical indicators can be distinguished as the most favorable soil. With the traditional approach, this soil should also be considered the most buffered. However, the buffering of soils is hidden not only in their agrochemical indicators, but also in the nature of microbiocenosis. In the course of further research, we found that 3 days after spraying the soil surface with Roundup herbicide at a concentration of 2.0% DM (glyphosate) at a working solution consumption of 696.6 l/ha in a model experiment with clone rootstocks of apple trees, an inhibitory effect on the soil microflora was already observed. Herbicide treatment did not lead to a significant decrease in the amount of yeast in all five studied soils. However, the decrease in the number of bacteria after herbicide treatment on different soils occurred to varying degrees: on leached chernozem – by 1.3 times, on dark gray forest soil - by 1.9 times, on floodplain granular soil – by 1.8 times, on floodplain layered soil – by 1.9 times, on sod–podzolic soil – in 1.3 times **(Table 2**).

**Table 2:** The Number of Microorganisms Depending on the Type of Soil When Treated with Roundup Herbicide, Thousands of Colony-Forming Units /g

| Option | Bacteria | Yeasts | Mold fungi | NMAFAM |
|---|---|---|---|---|
| **Leached chernozem** | | | | |
| Control | **6,5** | **8100,0** | **5,1** | **8111,6** |
| Herbicide | **5,3** | **8065,0** | **3,6** | **8073,9** |
| **Dark gray forest soil** | | | | |
| Control | **10,9** | **1350,0** | **6,5** | **1367,4** |
| Herbicide | **5,7** | **1345,5** | **5,4** | **1356,6** |
| **Floodplain granular soil** | | | | |
| Control | **4,5** | **930,0** | **4,0** | **938,5** |
| Herbicide | **2,5** | **895,5** | **1,9** | **857,8** |
| **Floodplain layered soil** | | | | |
| Control | **2,5** | **853,0** | **1,8** | **857,3** |
| Herbicide | **1,3** | **826,5** | **0,7** | **828,5** |
| **Sod-podzolic soil** | | | | |
| Control | **6,3** | **2560,0** | **6,1** | **2572,4** |
| Herbicide | **5,0** | **2532,0** | **4,9** | **2541,9** |
| $NSR_{05}$ | **0,3** | **60,5** | **0,3** | **70,3** |
| Accuracy of experience, % | **7,1** | **8,0** | **6,4** | **8,1** |

The decrease in the number of fungi after spraying with herbicide occurred to varying degrees: on leached chernozem – 1.4 times, on floodplain granular soil – 2.1 times, on floodplain layered – 2.6 times, on sod-podzolic and dark gray forest soils – only 1.2 times. A significant decrease in the total number of microorganisms (NMAFAM) due to the toxic effect of the herbicide was noted only on floodplain granular soil.

Thus, the bacterial complex of leached chernozem and sod-podzolic soil turned out to be the most resistant to the action of Roundup herbicide. The mushroom complex of forest soils (sod-podzolic and dark gray forest) turned out to be the most resistant to herbicidal load. In second place in this indicator is a very buffer soil – leached chernozem. And the most unstable fungal complexes to this effect were complexes of floodplain soils (granular and layered).

## Conclusions

- 3 days after spraying the soil surface with Roundup herbicide in a concentration of the active substance (glyphosate) 2.0% at a working solution consumption of 696.6 l/ ha in a model experiment with clone rootstocks of apple trees, an inhibitory effect on the soil microflora was already observed.
- Depending on the type of soil, the decrease in the number of bacteria was 1.3-1.9 times, soil fungi – 1.2-2.6 times.
- Soil yeasts proved to be more resistant to Roundup herbicide than bacteria and fungi. The bacteria were more resistant than the fungi. As a result, the total number of microorganisms significantly decreased only on floodplain granular soil.
- The most resistant bacterial complex to the action of Roundup herbicide turned out to be a complex of leached chernozem and sod-podzolic soil.
- The most resistant mushroom complex to herbicidal load was a complex of forest soils (sod-podzolic and dark gray forest). In second place in this indicator is a very buffer soil – leached chernozem. And the

most unstable fungal complexes to this effect were complexes of floodplain soils (granular and layered).

- Despite the less favorable agrochemical properties of forest soils (dark gray forest and sod-podzolic) compared to leached chernozem, their buffering to the bactericidal and fungicidal action of the herbicide turned out to be the same high.

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