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PHOSPHATE NUTRITION AND YIELD OF WINTER WHEAT UNDER THE INFLUENCE OF FERTILIZERS AND POLIMIKSOBAKTERYN

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Aim. To study the features of phosphorus nutrition of winter wheat under the influence of different doses of mineral fertilizers and microbial preparation Polimiksobakteryn. **Methods.** The phosphatase activity in rhizosphere soil of winter wheat was determined photocolorimetrically by the method of Geller and Ginsburg, the phosphorus content in plants – as described by Denizhe in the modification of Bouvatier. **Results.** The phosphatase activity in the rhizosphere soil of winter wheat plants increases due to the application of a microbial preparation and mineral fertilizers in low doses. This increases both the absorption of phosphorus by plants and their yield. **Conclusions.** Growing winter wheat on the leached black soil with dose-relevant introduction of mineral fertilizers in doses, not exceeding $N_{60}P_{60}K_{60}$, and the use of Polimiksobakteryn improve phosphorus nutrition of wheat plants and promote the increase in the yield of crops.

Key words: mineral fertilizers, Polimiksobakteryn, winter wheat, phosphatase activity, phosphate nutrition.

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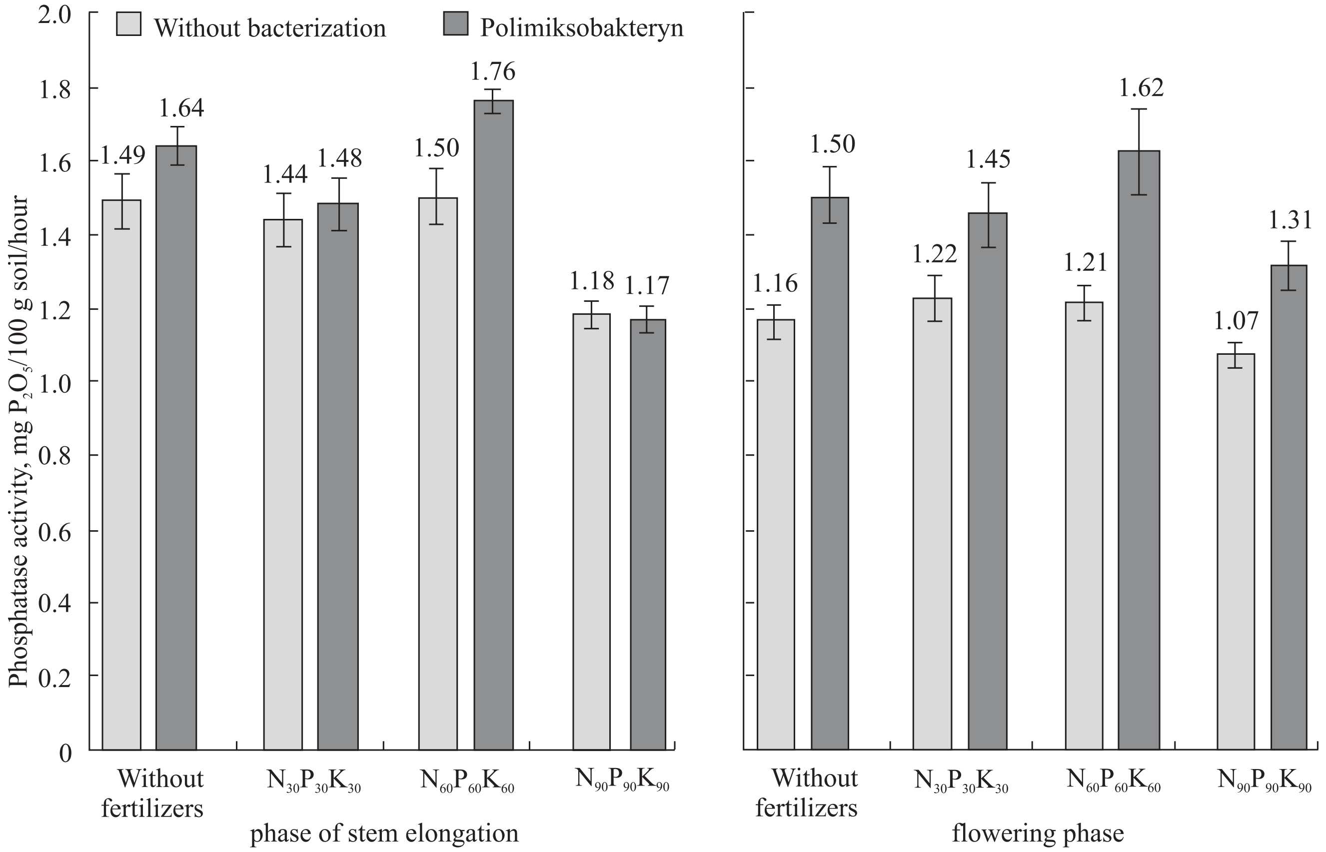
INTRODUCTION

One of the urgent problems of modern agriculture of Ukraine is to optimize phosphorus nutrition of crops, which is due to the key role of phosphorus in crop production process and the low natural content of its mobile compounds in soils [1]. The application of mineral fertilizers may optimize phosphorus nutrition of plants, but today the level of their use in Ukraine has decreased more than 5-fold [2]. In addition, due to the ability of soils to fix phosphorus, its amount, withdrawn by plants from fertilizers, does not exceed 20–25 % [3]. In these conditions an important technological method that can increase the solubility of phosphate in the soil is the use of microbial preparations based on phosphate mobilizing microorganisms [4]. It is known that microorganisms synthesize the complex of biologically active substances including the enzymes. Noteworthy among the latter are the phosphatases – proteins that are directly involved in the hydrolysis of organic phosphates [5, 6]. Using microbial preparations, based on active strains of phosphate mobilizing bacteria, it is possible to adjust the composition of microbial communities of plants root zone and to improve their phosphate nutrition of crops [7].

The aim of our study was to examine phosphorus nutrition of winter wheat under the influence of different doses of mineral fertilizers and microbial preparation Polimiksobakteryn.

MATERIALS AND METHODS

The study was conducted during 2011–2013 with winter wheat cultivar Sonechko in the stationary field experiment of the Institute of Agricultural Microbiology and Agroindustrial Production NAAS on meadow black soil which contains 2.12 % of humus, 95.2 mg/kg of easily hydrolyzed nitrogen, 226 mg/kg of mobile phosphorus (by Chirikov), 108 mg/kg of exchangeable potassium (by Maslov), pH_{salt} – 5.30, grain size distribution of the arable soil layer (by Kaczynski): content of fractions 0.1–0.25 mm, % – 5.6; 0.25–0.05 mm, % – 18.7; 0.05–0.01 mm, % – 52.2; 0.01–0.005 mm, % – 6.4; 0.005–0.001 mm, % – 6.0; sum of fractions < < 0.001 mm (clay), % – 16.7; sum of fractions <



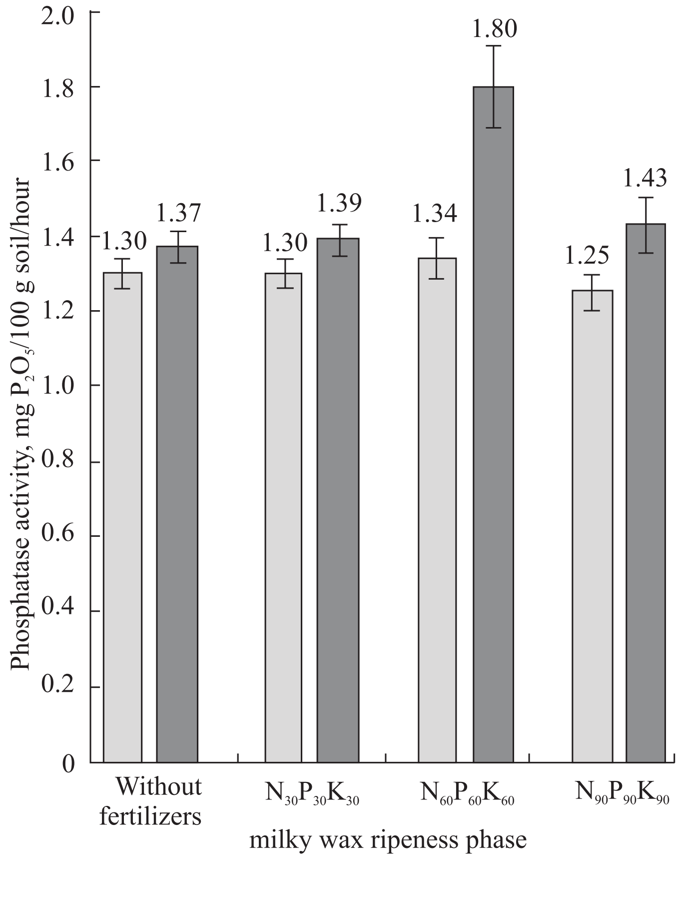


Fig. 1. The effect of bacterization and different doses of fertilizers on the phosphatase activity in soil rhizosphere of winter wheat plant cultivar Sonechko

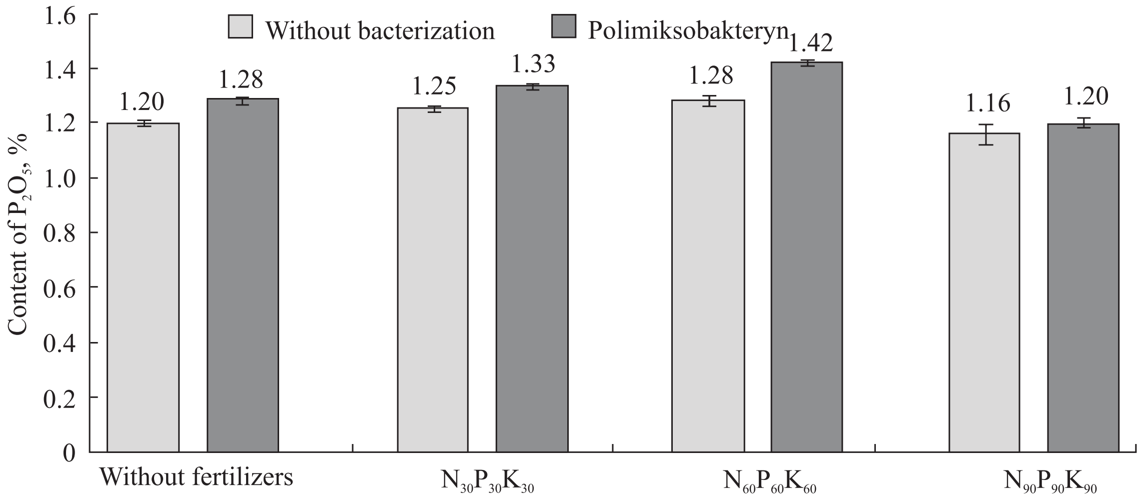


Fig. 2. Phosphorus content in the grain of winter wheat cultivar Sonechko

< 0.01 mm, % (physical clay) – 29.1, the diversity of soil – clayish coarse loamy soil.

The scheme of experiment with wheat included the following variants:

Background I – without bacterization:

1. without fertilizer (control);
2. $N_{30}P_{30}K_{30}$ (N_{20} in autumn + N_{10} in the tillering phase);
3. $N_{60}P_{60}K_{60}$ (N_{20} in autumn + N_{40} in the tillering phase);
4. $N_{90}P_{90}K_{90}$ (N_{20} in autumn + N_{40} in the tillering phase + N_{30} at the stem elongation stage);

Background II – bacterization by Polimiksobakteryn
5–8 – the same options (variants) of fertilization.

The area of research plot was 86.4 m^2 (7.2 × 12.0), the experiment was repeated four times. The farming culture of winter wheat was common. The bacterization of winter wheat seeds with Polimiksobakteryn (TS U 24.1-00497360-004:2009) was conducted according to CS 01.11-37-782 [8].

The samples of plant rhizosphere soil for analysis were taken during the following phases of wheat plant development: stem elongation, flowering and milky wax ripeness. The total phosphatase activity of rhizosphere soil of winter wheat plants was determined by the method of Geller and Ginsburg. The phosphorus content in winter wheat plants was determined as described by Denizhe in the modification of Bouvatier [9].

The progress of the field stationary experiment, the registration of crop yield and the statistical processing of the results were performed according to the conventional methods [10].

RESULTS AND DISCUSSION

The determination of phosphatase activity of wheat plant rhizosphere soil in dynamics demonstrated that during the vegetation period of wheat the phosphatase activity increased in all the backgrounds of mineral fertilization, except the highest dose of the fertilizer ($N_{90}P_{90}K_{90}$). The application of microbial preparation Polimiksobakteryn has a positive effect on the enzyme activity at all the stages of plant development, especially on the background of $N_{60}P_{60}K_{60}$. Thus, at the stage of stem elongation it increased by 0.26 mg P_2O_5/100 g soil/hour for the mentioned variant; in the flowering phase the difference between the variant with bacterization and without it was 0.41 mg P_2O_5/100 g soil/hour; in milky wax ripeness phase under the bacterization conditions the phosphatase activity of rhizosphere soil was 1.80 mg P_2O_5/100 g soil/hour (in the variant without bacterization – 1.34 mg P_2O_5/100 g soil/hour) (Fig. 1).

Similar specificities of the influence of Polimiksobakteryn and mineral fertilizers on the studied parameters were observed in all the years of research.

The influence of the microbial preparation on the hydrolysis of rhizosphere phosphate affected the phosphate nutrition of winter wheat plant soil. The phosphorus content in the leaves of wheat plants in the phase of milky wax ripeness increased compared with the control from 0.28 % to 0.37 % due to the effect of Polimiksobakteryn on the background of $N_{60}P_{60}K_{60}$ (Table 1). In case of bacterization on the background of $N_{60}P_{60}K_{60}$ the phosphorus content in grain increased by 0.14 % (Fig. 2).

The use of Polimiksobakteryn in all the backgrounds of mineral fertilization contributes to the increase of total phosphorus withdrawal with the yield of winter wheat. The highest withdrawal of phosphorus with the grain occurs under the influence of Polimiksobakteryn on the background of $N_{60}P_{60}K_{60}$ – 48.3 kg/ha, while in the variant without bacterization – 35.7 kg/ha, phosphorus withdrawal with straw – 37.2 kg/ha and 27.4 kg/ha, accordingly.

These changes contributed to the increase in the yield of crops (Table 2). Thus, comparing the yield of winter wheat in the experiment block without in-

Table 1. The effect of bacterization and fertilizers on phosphorus content in the leaves of winter wheat plant cultivar Sonechko

Variants of the experiment	The content of P_2O_5, %		
	phase of plant development		
	stem elongation	flowering	milky wax ripeness
Background I – without bacterization			
Without fertilizers (control)	0.50 ± 0.01	0.45 ± 0.01	0.22 ± 0.01
Mineral ($N_{30}P_{30}K_{30}$)	0.53 ± 0.01	0.48 ± 0.01	0.30 ± 0.01
Mineral ($N_{60}P_{60}K_{60}$)	0.56 ± 0.01	0.49 ± 0.01	0.28 ± 0.01
Mineral ($N_{90}P_{90}K_{90}$)	0.56 ± 0.01	0.49 ± 0.01	0.32 ± 0.01
Background II – bacterization by Polimiksobakteryn			
Without fertilizers	0.54 ± 0.01	0.53 ± 0.01	0.31 ± 0.01
Mineral ($N_{30}P_{30}K_{30}$)	0.58 ± 0.01	0.53 ± 0.01	0.33 ± 0.01
Mineral ($N_{60}P_{60}K_{60}$)	0.60 ± 0.01	0.55 ± 0.01	0.37 ± 0.01
Mineral ($N_{90}P_{90}K_{90}$)	0.56 ± 0.01	0.55 ± 0.01	0.34 ± 0.01

Table 2. The effect of fertilizers and bacterization on the yield of winter wheat cultivar Sonechko

Variants of the experiment	The average yield, t/ha	Surplus			
		with each subsequent dose of fertilizers		due to bacterization	
		t/ha	%	t/ha	%
Background I – without bacterization					
Without fertilizers (control)	3.97	–	–	–	–
Mineral ($N_{30}P_{30}K_{30}$)	4.43	0.46	11.59	–	–
Mineral ($N_{60}P_{60}K_{60}$)	4.66	0.23	5.19	–	–
Mineral ($N_{90}P_{90}K_{90}$)	4.82	0.16	3.43	–	–
Background II – bacterization by Polimiksobakteryn					
Without fertilizers	4.24	–	–	0.27	6.80
Mineral ($N_{30}P_{30}K_{30}$)	4.77	0.53	12.50	0.34	7.67
Mineral ($N_{60}P_{60}K_{60}$)	5.23	0.46	9.64	0.57	12.23
Mineral ($N_{90}P_{90}K_{90}$)	5.42	0.19	3.63	0.42	12.45
LSD_{05} in experiment	0.39				
for agricultural background	0.26				
for inoculation and interaction	0.17				

oculation with the indices of variants with preplanting bacterization of seeds with Polimiksobakteryn, we can conclude about the equivalence of the influence of microbial preparation on the culture productivity and the influence of certain doses of mineral fertilizers. For example, the yield of wheat in the variant $N_{30}P_{30}K_{30}$ + bacterization is the same as that for the introduction of fertilizer doses $N_{90}P_{90}K_{90}$ into the soil without bacterization.

The yield surplus for each subsequent dose of fertilizers in the experiment decreases naturally, but while using Polimiksobakteryn, the decrease is not as rapid as is the case of the corresponding variants without bacterization. It is an indirect reflection of the increasing degree of assimilation of the active ingredient of fertilizer under the influence of the microbial preparation. Similar features were observed earlier in the experiments with other crops [7].

CONCLUSIONS

Growing winter wheat on the leached black soil with dose-relevant introduction of mineral fertilizers in the doses, not exceeding $N_{60}P_{60}K_{60}$, and the use of Polimiksobakteryn improve the phosphorus nutrition of wheat plants and the increase in the yield of crops.

Фосфорне живлення та урожайність пшениці озимої за дії добрив та поліміксобактерину

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Мета. Вивчити особливості фосфорного живлення пшениці озимої за впливу різних доз мінеральних добрив та мікробного препарату Поліміксобактерину. **Методи.** Фосфатазну активність ризосферного ґрунту пшениці озимої визначали фотоколориметрично за методом Геллер та Гінзбург, вміст фосфору в рослинах – за методом Деніже в модифікації Буватьє. **Результати.** У ризосферному ґрунті рослин пшениці озимої при застосуванні мікробного препарату та внесенні мінеральних добрив у невисоких дозах зростає фосфатазна активність. При цьому збільшується засвоєння фосфору рослинами, підвищується урожайність. **Висновки.** При вирощуванні пшениці озимої на чорноземі вилуженому роздрібне внесення мінеральних добрив у дозах, що не перевищують $N_{60}P_{60}K_{60}$, і застосування Поліміксобактерину сприяє покращенню фосфорного живлення рослин пшениці і зростанню урожайності культури.

Ключові слова: мінеральні добрива, Поліміксобактерин, пшениця озима, фосфатазна активність, фосфорне живлення.

Фосфорное питание и урожайность пшеницы озимой под влиянием удобрений и полимиксобактерина

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Цель. Изучить особенности фосфорного питания пшеницы озимой под влиянием различных доз минеральных удобрений и микробного препарата Полимиксобактерина. **Методы.** Фосфатазную активность ризосферной почвы определяли фотоколориметрически по методу Геллер та Гинзбург, содержание фосфора в растениях пшеницы озимой – по методу Дениже в модификации Буватье. **Результаты.** При выращивании пшеницы озимой на черноземе выщелоченном применение Полимиксобактерина и минеральных удобрений в невысоких дозах способствует усилению фосфатазной активности в ризосферной почве растений. Это сопровождается улучшением фосфорного питания и повышением урожайности. **Выводы.** При выращивании пшеницы озимой на чорноземе выщелоченном дробное внесение минеральных удобрений в дозах, не превышающих $N_{60}P_{60}K_{60}$, и применение Полимиксобактерина способствует улучшению фосфорного питания растений пшеницы и увеличению урожайности культуры.

Ключевые слова: минеральные удобрения, Полимиксобактерин, пшеница озимая, фосфатазная активность, фосфорное питание.

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