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The effect of macro- and microfertilizers on agrochemical soil characteristics and spring wheat yield under conditions of the Right bank of the Volga-River in Saratov region

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Abstract

The paper specifies how the application of micro- and macrofertilizes changes typical black soil nutrient regime and physicochemical properties in spring wheat plantings. It was determined that the most acceptable nutrient regime was formed with combined usage of ammophos and such chemicals as Micromac and Microel. During these experiments nitrogen concentration amounted to 8.50 and 8.25 mg kg^{-1} of the soil, and available phosphorus was 60.0 and 57 mg kg^{-1}, respectively. The control gave the maximum amount of exchangeable potassium (242.5 mg kg^{-1}), whereas the lowest rate was registered with combined usage of Micromac and Microel against the background of ammophos (231.6 mg kg^{-1}). At the end of growth the nutrient regime significantly degraded due to the increasing plant nutrition of spring wheat.

The influence of fertilizers on soil cation content was analyzed. Total absorbed bases insignificantly increased in applying fertilizers compared to the control, particularly with combined usage of micro and macrofertilizers, when this amount reached 44.45 mg-equiv per 100 g of soil.

The highest yield has been observed with combined application of micro- and macrofertilizers, reaching 1.86 t ha^{-1}, while the lowest yield has been shown in the control (1.22 t ha^{-1}). The amount of calcium and magnesium cautions increased within SAC.

Keywords: cations, Micromac, Microel, nitrate nitrogen.

Introduction

Currently, agricultural industry faces the main issue to create a proper plant nutrition system, which enables the full scale implementation of grade genetic ability obtaining potential yield with target values. This problem can be solved by thorough science-based application of fertilizers. Thereby, the efficient use of fertilizers, i.e. proper selection of fertilizers, their rates, terms and methods of application are the items of the agenda (Gaisin, 2003; Zakharova, 2007; Burmistrova *et al.*, 2011).

In order to realize spring wheat potential, practicing mineral nutrition by means of first-order macroelements is considered to be insufficient. In this aspect the most significant are growth stimulators and polynutrient microfertilizers, which increase wheat plants persistence to diseases, stresses and yielding ability (Aristarhov, Tolstousov, 2010).

Over the last years high effective chelated microfertilizers of a new generation became a frequent practice, though their usage stays underexplored in Saratov region. In essence, the necessity of studying these fertilizers influence on plant growth that allows rising of crop yields and kernel quality with ecological friendly agricultural practice is evident (Gualiyahmetov, Pahomova, 2007; Zakharova, 2007).

Our research aimed at studying the effect of macro- and micromanures on soil nutrient regime, its physicochemical traits and spring wheat yield under dryland conditions of the right bank of the Volga-river in Saratov region.

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Materials and methods

The research was conducted at the farm «Zemlianye Hutora» of Atkarsk municipality of Saratov region. Trial establishment was done according to practical standards for dryland conditions (Dospehov, 1985).

The following variants were used in the experiment: 1) Untreated control; 2) Ammophos; 3) Seed treatment with Micromac; 4) Leaf fertilizing with Microel; 5) Seed treatment with Micromac + leaf fertilizing with Microel; 6) Ammophos + seed treatment with Micromac + leaf fertilizing with Microel.

The soil was fertilized according to typical recommendations for this landing area. Ammophos with nitrogen content of 12% and phosphorous of 52% was used in the trials and was applied during the sowing of wheat. Before sowing all the seeds were treated with Micromac at a dose of 2 l t^{-1}. Chemical Microel was used for leaf fertilizing at a dose of 200 g ha^{-1}. First treatment using her-bicide Dianat by means of sprayer Amazone was taken during tillering stage whereas the second one was provided in combination with fungicide Rex-S at heading stage.

Under laboratory and field conditions the following researches were done for all the variants:

1) Nitrate nitrogen concentration was determined colorimetrically in the presence of phenoldisulfonic acid; labile phosphorous was calculated using Chirikov's method while exchangeable potassium was obtained by Maslova; total exchangeable bases and combined acidity were measured according to Kappen-Hilkovic method; amount of Ca++, Mg ++ was determined by the thrilonometric method.

2) Actual grain yield was assessed in all the variants with overall harvesting. The measurements were re-counted in t ha^{-1} related to kernel standard moisture content.

3) Mathemetical treatment was performed using dispersion analysis.

We conducted the field experiment on ordinary black soil moderate humic and midloamy.

The researches were carried out during 2010-2011 crop years. Although the weather of 2011 was favorable for spring wheat growth and ripening, 2010 crop year turned out to be extreme dry.

Agrotechnology involved in spring wheat cropping in the test plot was the same as that one used for seeding in the very farm. The previous crop was winter wheat after land laying complete fallow.

Soft spring wheat cultivar Dobrynya was used in the experiment.

Results

Nutrient soil regime is known to be the most significant in increasing spring wheat yields, while nitrogen remains as the main element for plant nutrition. Since nitrates are the end products of nitrogen fertilizers transformation in the soil and the main element for plant nutrition, it's sufficient viewing this form of mineral nitrogen.

The results of this research have shown that the highest mean annual dose of nitrate nitrogen ($N-NO_3$) is accumulated in the soil at spring wheat seeding fertilized with ammophos at a rate of 8.50 mg kg^{-1}, that is 1.8 mg kg^{-1} higher than that in the control (Table 1).

Seed treatments with Micromac, leaf fertilizing with Microel and their combined application led to nitrate N reduction in the soil in spring wheat plantings, where its amount was 6.51, 6.50 and 6.31 mg kg^{-1} per soil, respectively. When using ammophos, Micromac and Microel in combination the amount of nitrate nitrogen was 8.25 mg kg^{-1}, that is 0.93 mg kg^{-1} higher than that in the control, but 0.25 mg kg^{-1} less compared to that by using only ammophos. Apparently, the amount of nitrate N decreased due to the intense plant nutrition and growing.

Besides nitrogen, phosphorous refers to the essential elements of plant nutrition.

The results of our research demonstrated that the highest content of available phosphorous was observed in the second variant of the experiment, where its amount reached 60 mg kg^{-1} (Table 1). However, the application of microfertilizers resulted in decreasing the content of available phos-phorous, which was caused by extensive spring wheat nutrition.

Potassium affects the process of nitrogenous plant nutrition. For recent years the tendency of subtracting potassium from the soil has been observed, so it's especially noteworthy.

In our experiment because the soil has high potash level, potassium fertilizers are not applied, but the percentage of exchangeable potassium varies throughout the variants of the experiment. Using of micro- and macrofertilizers insignificantly decreased the amount of exchangeable potassium in the soil (Table 1).

At the end of vegetation stage the amount of soil nutrients reduced because of extensive nutrition of spring wheat plantings. The role of soils in maintenance of agroecosystems stability and providing environmentally friendly production is currently found to be significant. At the same time values of physicochemical soil properties are also important.

We studied the effect of fertilizer application on caution ratios in the soil.

The carried researches have found the insignificant increasing of total absorbed bases in fertilized soil compared with the test control, especially in the variant (6) of joint application of macro- and micromanures, when this ratio showed 44.45 mg-equiv per 100 g of soil (Table 2). The total number of calcium and magnesium cautions also increased within SAC. Hydrolytic soil acidity fell within range from 1.7 to 3.2 mg-equiv per 100 g of soil according to experiment variants. These soils are considered to be base-saturated since the degree of base saturation is 94%.

Table 1. Content of nutrients in ordinary black soil fertilized in spring wheat plantings, mg kg^{-1}.

Experiment variants	Tillering beginning			Vegetation end		
	NO_3	P_2O_5	K_2O	NO_3	P_2O_5	K_2O
1. Control	7.32	53.9	242.5	4.10	36.9	230.1
2. Ammophos	8.50	60.0	242.0	5.48	44.8	228.7
3. Micromac	6.51	51.8	241.9	3.15	35.0	228.2
4. Microel	6.50	51.1	235.7	3.12	34.4	225.0
5. Micromac + Microel	6.31	49.5	232.4	2.94	33.5	212.9
6. Ammophos + Micromac +Microel	8.25	57.3	231.6	3.89	42.3	208.1

Table 2. Impact of fertilizers on physicochemical soil properties.

Experiment variants	S, mg-equiv per 100 g of soil	SCa+Mg, mg-equiv per 100 g of soil	Ca, mg-equiv per 100 g of soil	Mg, mg-equiv per 100 g of soil	Hr, mg-equiv per 100 g of soil	V, %
1. Control	35.40	32.78	27.15	5.45	1.7	94
2. Ammophos	43.95	40.80	34.00	6.80	2.8	94
3. Micromac	44.00	40.95	34.12	6.83	2.9	94
4. Microel	44.20	41.00	34.18	6.82	3.1	94
5. Micromac + Microel	44.25	41.27	34.28	6.99	2.9	94
6. Ammophos + Micromac + Microel	44.45	41.38	34.38	67.00	3.2	94

Table 3. Fertilizer effect on spring wheat yield, t ha^{-1}.

Experiment variants	Crop yield, t ha^{-1}		
	2010	2011	Average
1. Control	0.71	1.72	1.22
2. Ammophos	1.20	2.25	1.73
3. Micromac	0.84	1.80	1.32
4. Microel	0.78	1.75	1.26
5. Micromac + Microel	1.09	1.98	1.54
6. Ammophos + Micromac + Microel	1.32	2.41	1.86
LSD_{05}	0.019	0.031	

Average spring wheat yield over two years has showed significance difference from 0.71 to 2.41 t ha^{-1} depending on the experiment variants (Table 3).

The lowest rate was obtained on the test control, when average crop yield was 1.22 t ha^{-1}, whereas the highest one was marked in the variant (6) of combined application of macro- and microfertilizers, making up 1.86 t ha^{-1}, that is 0.64 t ha^{-1} higher than in the control. When ammophos was separately used the crop yield went down in comparison with variant 6 and ranged from 1.20 to 2.25 t ha^{-1}. With using of chemicals Micromac and Microel severally average yield varied from 0.84 to 1.75 t ha^{-1}, while the combined application increased yield up to 1.54 t ha^{-1} (0.32 t ha^{-1} higher than on the control).

Parameters of spring wheat yield differed over the whole observation period. The maximum yield was in 2011.

Conclusions

Throughout the two-year period it was obtained that:

1. The most acceptable nutrient regime was reached with input of ammophos and combined usage of ammophos and such chemicals as Micromac and Microel. During these experiments nitrogen concentrations of 8.50 and 8.25 mg kg^{-1} of the bulk soil were measured, and available P was 60.0 and 57 mg kg^{-1}, respectively. The control gave the extreme amount of exchangeable K (242.5 mg kg^{-1}), whereas the least was registered with combined usage of Micromac and Microel against the background of ammophos (231.6 mg kg^{-1}).

2. The optimal physicochemical traits were recorded with combined usage of marco- and microfertilizers.

3. The combined application of micro- and macrofertilizers in 6 variant resulted in the highest yield at 1.86 t ha^{-1} whereas the lowest yield was marked in the control (1.22 t ha^{-1}).

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