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Zeolite Efficiency in The Fertilization System of Spring Wheat.

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ABSTRACT

The article is devoted to the study of the possibility of using zeolite of the Yushansky deposit in the Ulyanovsk region in the fertilization system for spring wheat. It has been found that the application of zeolite in pure form as a fertilizer in a dose of 500 kg/ha makes it possible to raise the grain yield of spring wheat by 0,47 t/ha (20 %) when it is cultivated on typical black soil in combination with carbamide – by 1,04 t/ha (44 %).
Keywords: spring wheat, yield, fertilizer, zeolite.

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INTRODUCTION

The necessity to use natural silicon containing rocks in farming is stipulated by, first of all, the fact that commercial silicon fertilizers are not available, whereas the expedience of applying the latter has been proved with multiple studies [1-7] and some of them in efficiency are frequently not inferior to traditional mineral fertilizers. U.G. Distanov's utterance is right in this respect that the use of non-traditional mineral raw materials which high silicon rocks belong to, and

The work has been completed with the assistance of "Keramzit" Ltd. that owns the Yushansky zeolite deposit.

zeolites as well can be «considered as the indicator of scientific and technical progress» by right [8].

The Ulyanovsk region possesses rich reserves of silicon-containing rocks (diatomites, zeolites, bergmehls, bentonites).

Natural zeolites are aqueous caged aluminosilicates of alkali and alkali and earth metals with a general formula

$M_{x/n}[(AlO_2)_x(SiO_2)_y * ZH_2O]$,

Where, M – kation with valency n, Z – number of water molecules, the ratio of y/x has different meanings and is usually within the range from 1 to 5.

The matrice of zeolites is built from four-, five-, six-figured and more rings formed by silicon and oxygen tetrahedra. A certain number of atoms is replaced by aluminium. As a result of such structure the system of cavities and canals interconnected with the environment is formed in intracrystalline space of zeolites where kations of calcium and sodium are located, and more rarely kations of potassium, magnesium, barium, strontium, lithium and molecules of «zeolite» water.

Porous open microstructure of zeolites predetermines their unique and useful properties and especially for the application in agriculture. The possibility of wide application of zeolite-containing rocks in agriculture is stipulated by not only their unique adsorptive and structural properties of silicon but also unique properties of silicon. The content of silicon in zeolites of the Yushansky deposit amounts to 58%, including amorphous silicon up to 51%.

The abovementioned stipulates the necessity of studying the possibility of using mineral raw resources and zeolites among them as a fertilizer of crops. The studies were conducted in 2016. This article contains the results of the efficiency study of zeolite mined at the Yushansky deposit in the Ulyanovsk region in the fertilization system of spring wheat.

Objects and methods of study

The objects of the study were:

- the soil – typical black soil of average thickness, average clayloam with the humus content of 4,7 %, available phosphorus and potassium 196 and 206 mg/100 g, pH_{KCl} 6,3 – 6,7;

- the crop – spring wheat Margarita;

- fertilizers – azophoska with content of nitrogen, phosphorus and potassium in 16 % and carbamide with nitrogen content of 46 %;

- zeolite of the Yushansky deposit of the Ulyanovsk region that has in its composition: SiO_2 general 54,11 – 58,36 %, SiO_2 amorphous 4,31 – 51,26 %, Al_2O_3 5,8 – 6,44 %, Fe_2O_3 1,81 – 3,10 %, CaO 12,60 – 14,95 %, MgO 1,77 – 2,00 %, MnO up to 0,01 %, K_2O 1,16 – 1,90 %, Na_2O 0.03 – 0,27 %, P_2O_5 0,08 – 0,49 %.

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The experiment design was composed of the following variants:

1. Control group (without fertilizers)
2. Zeolite 500 kg/ha
3. N40P40K40 (azophoska)
4. N40P40K40 + zeolite 500 kg/ha
5. N40 (carbamide) + zeolite 500 kg/ha

The area of the registration plots is 20 m^2, their layout is randomized, four time replication, the analytical replication of soil and plant samples is three-fold. The tested fertilizers and zeolite in appropriate doses were applied for the main soil cultivation.

Weather conditions of the vegetation period were favorable for growth and development of crops. The technology of cultivating spring wheat is commonly accepted in the Ulyanovsk region.

The field experiments and laboratory analyses were carried out in strict conformity with the methodical requirements and state standards.

The yield registration was conducted in view of the total area of the plot with recalculation for 100 % purity and 14 % of moisture (GOST 77548-97).

RESULTS AND DISCUSSION

Table 1 contains agrochemical values of typical black soil and their change under the influence of zeolite application and mineral fertilizers while cultivating spring wheat.

Table 1: Content of main nutrients in the soil layer of 0 – 30 cm under the spring wheat crops

№	Variant	Stages of plant development								
		Seedlings			Tillering			Full maturity		
		$N\text{-}NH_4$ $+N\text{-}NO_3$	P_2O_5	K_2O	$N\text{-}NH_4$ $+N\text{-}NO_3$	P_2O_5	K_2O	$N\text{-}NH_4$ $+N\text{-}NO_3$	P_2O_5	K_2O
1	Control group	13,7	161	149	18,2	156	155	10,3	147	146
2	Zeolite 500 kg/ha	14,3	163	157	18,7	157	160	10,8	149	147
3	N40P40K40 (azophoska)	21,1	172	165	24,0	165	169	13,7	157	157
4	N40P40K40 + zeolite 500 kg/ha	21,2	181	174	24,0	168	170	14,0	163	167
5	N40 (carbamide) + zeolite 500 kg/ha	21,3	162	159	24,8	156	154	14,2	149	157
LSD_{05}		0,6	6	5	0,2	7	3	0,3	7	7

The data analysis in the table shows that by the beginning of crop vegetation the fertilizers applied in the fall contributed to an improvement of nutritive regime of the soil. If we did not observe perceptible changes in the nutrient content in the arable layer when zeolite was applied in a dose of 500 kg/ha, they were significant in the option with a complex mineral fertilizer and its combined use with zeolite, as well as the application of zeolite with carbamide: differences were more than 7 mg/kg of mineral nitrogen, 10 – 20 mg/kg of available phosphorus and 10 – 15 mg/kg – potassium.

By mid vegetation of spring wheat the number of main nutrients increased both in the control group and, especially in the option with application of fertilizers, that is undoubtedly, stipulated by favorable conditions and intensification of soil microorganisms' activity [9].

Before the stage of full grain maturity the content of all elements naturally decreased owing to the intensification of their use to form the crop yield. Nevertheless, a high level of plant nutrition retained when fertilizers were applied and including zeolite, especially in the nitrogen content.

In this respect one should emphasize the variant of combined application of zeolite 500 kg/ha and carbamide 40 kg/ha (active substance). This variant also provided the plants with nitrogen in a full amount as the variant with application of the complete dose of NPK.

In the content of available phosphorus and potassium, the last variants had a relative advantage. However, taking into account the fact that the supply of typical black soil with movable compounds of phosphorus and potassium is high, but spring wheat is the crop that is very demanding of nitrogen, also from the point of view of forming high quality grain, so it is sufficient to apply carbamide together with zeolite in the soil (or any other nitrogenous fertilizer) in a dose of 40 kg of active substance for 1 hectare to optimize the nutrition regime.

The yield of crops is an integral efficiency indicator of all the agrothechnical practices used in their cultivation technologies. When it comes to the fertilization system, it must ensure the plant nutrition regime balanced with all the elements in any soil and climatic conditions. The yielding capacity of experimental crops and values of grain quality are given below (table 2).

While analyzing the data of the table one should pay attention to high efficiency of zeolite as a fertilizer, the application of which in the soil in a dose of 500 kg/ha makes it possible to raise the yield by 0,47 t/ha (20 %). Spring wheat is the crop which is demanding of the soil fertility and with application of mineral fertilizers the yield increases by 0,90 t/ha (34 %). Combined application of mineral fertilizers in doses of 40 kg. of active substance/ha of nitrogen, phosphorus and potassium and zeolite 500 kg/ha secures the yield gain of more than one tone per hectare (!). At the same time it is important to note that the yielding capacity of spring wheat when zeolite (500 kg/ha) and nitrogen (40 kg/ha) are used in the fertilization system in efficiency, judging by the LSD_{05} values, is not inferior to the variant where the full dose of fertilizers was used including phosphorus and potassium. Consequently, on leached black soils while cultivating spring wheat it is sufficient to apply zeolite in a dose of 500 kg/ha together with carbamide in a dose of 40 kg of active substance/ha to achieve the maximum result. The demand in phosphorus is partially satisfied at the expense of its transition to a more available state under the influence of amorphous earth silicon (monosiliceous acid) which is present in zeolite [1], and the supply of available potassium of this soil is very high.

Table 2: Yielding capacity of spring wheat, t/ha (2016)

№	Variant	Replication				Mean	Deviation from control	
		1	2	3	4		t/ha	%
1.	Control	2,55	2,41	2,21	2,32	2,37	-	-
2.	Zeolite 500 kg/ha	3,04	2,95	2,72	2,68	2,82	0,47	20
3.	N40P40K40	3,31	3,25	3,17	2,98	3,18	0,90	34
4.	N40P40K40 + zeolite 500 kg/ha	3,52	3,65	3,57	3,32	3,52	1,14	49
5.	N40 + zeolite 500 kg/ha	3,44	3,50	3,45	3,27	3,42	1,04	44
	$LSD_{0,5}$	-	-	-	-	0,13	-	-

With this the quality of the product improves (table 3).

Table 3: Spring wheat grain quality, % (2016)

№ №	Variant of the experiment	Values			
		Nitrogen	Phosphorus	Potassium	Gluten
1	Control group	1,73	0,58	0,39	26,3
2	Zeolite 500 kg/ha	1,88	0,63	0,36	27,9
3	N40P40K40	1,98	0,67	0,38	27,4
4	N40P40K40+ Zeolite 500 kg/ha	1,91	0,67	0,41	28,6
5	N40 + Zeolite 500 kg/ha	1,97	0,68	0,40	28,5
LSD_{05}		0,06	0,05	0,04	0,8

The data of the table show that when zeolite in a dose of 500 kg/ha is applied, the grain quality of wheat considerably increases in the content of key elements (nitrogen, phosphorus, potassium) and gluten.

The application of zeolite together with carbamide in the fertilization system of spring wheat helps to obtain the grain of the first class in the content of gluten (> 28 %).

CONCLUSIONS

- While cultivating spring wheat on typical black soil it is sufficient to apply 500 kg/ha of zeolite and carbamide in the soil (or any other nitrogenous fertilizer) with a dose of 40 kg of active substance/ha to optimize the nutrition regime of plants.
- The highest yielding capacity of spring wheat was formed in the variant with combined application of zeolite with mineral fertilizers: the grain gain amounted to from 1,04 to 1,14 t/ha. The variant zeolite 500 kg/ha + N40 in efficiency was not inferior to the variant – 500 kg/ha + N40P40K40 – difference between them in the criterion of significance is not reliable.

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