ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Influence of Silicon Containing Preparations on Agrochemical Properties of Sod and Podzolic Soil and Yielding Capacity of Crops.

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ABSTRACT

The article contains the results of studying the changes in agrochemical properties of sod-podzolic light loam soil with the use of silicon containing preparations Siliplant, Energia-M, Mival-Agro and growth regulator Crezatsin in the cultivation technology of winter wheat and potato. A considerable increase in the content of available silicon in the arable layer of the soil has been found (by 1,6-1,8 and 3,4-4,6 times respectively before sowing winter wheat and planting potato). Mival Agro was the most effective in winter wheat cultivation, in potato cultivation – Energia-M and Mival-Agro: the grain yield increase amounted to 31 %, the yield of tubers – 37 and 32 % respectively.

Keywords: silicon containing preparations, Siliplant, Crezatsin, Energia-M, Mival-Agro, sod-podzolic soil, winter wheat, potato

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ISSN: 0975-8585

INTRODUCTION

An absolute necessity of providing the country with the required amount of domestically produced foodstuffs predetermines a wide application of contemporary science's advances in crop cultivation technologies. In this respect various biologically active substances with a comprehensive impact, including silicon containing ones, have been frequently used lately. The latter is connected with unique properties of silicon not only as a nutrient but also as a substance playing a very important role in biochemical and physiological processes and in the life of a plant on the whole [1,2,3,4,5,6,7,8].

The effectiveness of silicon containing growth stimulants was studied by a number of researchers [2, 3, 9, and 10]. However, they little dealt with the issues of changes that take place in the soil itself, in its nutritive mode, in particular, which is the basis of the plant's yielding capacity formation. The latter determined the purpose of our research – to study the influence of silicon containing preparations on agrochemical properties and winter wheat and potato yields.

OBJECTS AND METHODS

The studies were conducted at the potato growing enterprise «Elitkhoz» Ltd., Borsky district, the Nizhny Novgorod region. The designs of experiments implied a variant without treatment (control group), as well as variants with plants treated with growth stimulants Energia-M, Mival-Agro, Siliplant and Crezatsin.

Energia-M– is a siliceous auxin growth regulator of plants. This preparation is composed of triethanolammonium salt of orthocresooxihydroxiacetic acid, which is a synthetic phytohormone (biogenic amine) and an analog of phytohormones contained in plants; as well as 1-chlorometylsilatrane (silatsin), a representative of the group of chemical substances of silatranes in which silicon is in a biologically active form.

This preparation has an anti-oxidizing effect on crops directed to inhibiting lipid peroxidation in the cell membrane; adaptogenic effect directed to raising crops' hardiness to withstand extreme conditions during vegetation (drought, frosts, a sharp change of weather conditions, fungal and viral diseases and so on).

Mival-Agro is a silicon organic biostimulant of a complex effect. It is composed of triethanolammonium salt of orthocresooxihydroxiacetic acid (760 g/kg) and chlorometylsilatrane (190 g/kg). Besides, a silicon containing compound «Mival» composed of a phytohormone analog from the group of auxins – Crezatsin which is a phytoadaptive gene and a phyto anti-oxidant.

The action of the preparation is directed to protein synthesis and nucleonic acids in plant cells. It facilitates the strengthening of plants' protective properties, raises hardiness under extreme weather conditions. The application of Mival –Agro actively stimulates the root formation, contributes to the decline of root rot affecting plants including root rot of infectious etiology.

Siliplant is silicon containing liquid fertilizer. The preparation is composed of silicon and potassium (13-21 mg/l), trace elements in an easily available chelates form for plants (g/l): Fe – 0,44-0,54, Mg – 0,12-0,13, Cu – 0,09-0,27, Zn – 0,74-0,87, Mn– 0,32-0,37, Mo–0,06-0,074, Co–0,020-0,024, B– 0,094-0,112. Silicon in a complex with micro elements which the preparation is composed of frost and drought resistance, photosynthesis activity, facilitates an active growth of the root system and leaf apparatus. It takes an active part in nucleinic, protein and carbohydrate metabolism including protein and carbohydrate transport.

Crezatsin is a growth regulator, in a physiological sense it is an adaptive gene (adapt gene) of a broad spectrum of effect on plants and animals. It raises the organism resistance to a long term effect of unfavorable factors and diseases; contributes to the intensification of protein biosynthesis and nucleonic acids, increases the enzyme activity.

Treatment doses have been accepted in view of the manufacturers' recommendations (Table 1).

ISSN: 0975-8585

Table 1: Doses of preparations used in the experiment

№	Biopreparation	Application method			Application frequency
		soil	seeds	plants	
1	Energia-M	-	5 g/t	10 g/ha	three times
2	Mival-Agro	-	5 g/t	10 g/ha	three times
3	Siliplant	-	60 ml/t	3 l/ha	three times
4	Crezatsin	-	0,5 g/t	6 g/ha	three times

Treatment with each preparation was carried out three times: wheat seeds and potato tubers by means of soaking them in the preparation solutions; seedlings – of winter wheat in the phases of tillering and flowering, potato planting in the stage of the third pair of true leaves and the flower bud formation.

The soil of the experiment field – sod-podzolic light loam with the following agrochemical values: the humus content - 1, 2 %, pH- 4, 8 pH_{KCl}, mobile compounds of phosphorus - 86 mg/kg, potassium - 110 ml/kg; actual silicon -16 mg/kg, potential – 213 mg/kg.

Small plot experiments. The area of plots is $1m^2$; their layout is randomized, with four time replication. The analytical replication of soil samples is three-fold; all laboratory analyses were conducted according to existing state standards.

RESULTS AND DISCUSSION

The study results showed perceptible changes of agrochemical values of the sod-podzolic soil when using both silicon containing preparations and Crezatsin (tables 2 and 3), a non-silicon growth regulator in the cultivation technology of both crops (winter wheat and potato).

Table 2: Agrochemical values of the sod-podzolic soil sown to winter wheat

Variant	pH_{KCl}, units. pH	$NH_4^+ + NO_3^-$, mg/kg	P_2O_5, mg/kg	K_2O, mg/kg	Si, mg/kg	
					actual	potential
Control	4,81	21,9	90	107	16	213
Crezatsin	4,92	22,0	76	115	20	210
Siliplant	4,96	21,9	81	112	25	201
Energia-M	4,90	18,3	83	100	31	194
Mival-Agro	4,94	20,3	94	92	37	186
LSD_{05}	0,13	3,2	8	10	14	16

Table 3: Agrochemical values of the sod-podzolic soil sown to potato

Variant	pH_{KCl}, units. pH	$NH_4^+ + NO_3^-$, mg/kg	P_2O_5, mg/kg	K_2O, mg/kg	Si, mg/kg	
					actual	potential
Control	4,83	31,8	89	100	13	192
Crezatsin	4,86	31,7	69	111	21	174
Siliplant	4,95	28,9	74	107	44	160
Energia-M	4,88	29,1	86	93	56	146
Mival-Agro	4,91	28,0	77	80	60	142
LSD_{05}	0,11	4,4	13	10	19	23

While analyzing the data of the tables, what stands out is that the application of silicon containing preparations in the soil together with seeds and planting material was accompanied by a change of all agrochemical values in this or that respect, whereas with the use of a non silicon preparation Crezatsin, there were no reliable differences (judging by LSD_{05}) between these variants and control group. The latter gives a possibility to assume that the changes in the agrochemical state of the soil are caused, first of all, by the presence of silicon in preparations in an organic form. At the same time the content of actual silicon in the soil both under winter wheat and potato increased in 1, 6-1, 8 and 3, 4-4, 6 times respectively. The amount of

potential available silicon naturally decreased which testifies to its transition into a more available from for plants.

However, it should be noted that a very small amount of preparations comes into the soil with seeds and planting material and it is hardly possible to explain their influence on the agrochemical state of the soil due to the direct effect of silicon. In our opinion, the influence of silicon containing preparations as compounds possessing a wide spectrum of biochemical and physiologic activity is manifested indirectly through the activity increase of major functional groups of soil microorganisms (silicate, phosphate reducing and others)

As far as other elements are concerned (NH_4^++NO_3^-, P2O5, K2O) their content towards the end of crop vegetation reduced which is quite explicable by plants' active consumption to form the yield. Nevertheless, on variants with the use of silicon containing preparations and control variant the differences were practically lower than the reliable values which testify to more favorable nutrition modes for plants on these variants.

Beyond any doubt, the identified natural tendencies of agrochemical values change under the influence of silicon containing preparations exerted influence on the yield formation of experimental crops (table 4).

As we can see from the data of the table given, all silicon containing growth regulators contribute to a reliable yield increase of both crops: by 2,80-3,39 of winter wheat grain and by 4,6-9,1 t/ha of potato tubers. Mival-Agro turned out to be the most effective in the cultivation technology of winter wheat (the yield gain 0, 78 t/ha). This seems to have happened because it is composed of not only silicon containing Mival but also Crezatsin, and here their synergetic interaction was noted.

Table 4: Yields of winter wheat (grain) and potato (tubers), t/ha

Variant	Winter wheat		Potato	
	Yield	± to control	yield	± to control
Control	2,51	-	24,6	-
Crezatsin	2,64	0,13	27,1	2,5
Siliplant	2,86	0,35	29,2	4,6
Energia-M	2,80	0,29	33,7	9,1
Mival-Agro	3,29	0,78	32,5	7,9
LSD_{05}	0,24		4,0	

Mival-Agro had a similar effect on the yield formation of potato tubers. It should be pointed out that when cultivating this crop Energia-M is not inferior to Mival-Agro and even exceeds it slightly in the influence on yields. However, the difference between them is statistically unreliable. The latter can be explained by the fact that Energia-M significantly increases plants' resistance to fungal and viral diseases, but potato is frequently affected by them.

Both crops (winter wheat and potato) are silicon loving plants and their yielding capacity in this experiment is in direct relation to the content of actual silicon in the soil solution.

CONCLUSION

Silicon containing growth regulators essentially influenced agrochemical values of sod-podzolic light loam soil, first of all, the availability of silicon. Its content in the arable soil layer underneath winter wheat seedlings increased in 1, 6-1, 8 times, under potato seedlings in 3, 4-4, 6 times. Changes in the content of other nutrients in the soil are less significant, which decreased towards the end of crop vegetation. However, at the same time a more favorable regime of plant nutrition was observed in the soil than in the control group and on the plot with application of the non-silicon preparation Crezatsin.

The most effective in cultivating winter wheat was Mival-Agro, a biologic growth stimulant of a complex effect; the grain yield gain amounted to 1,77 t/ha or it increased by 31 %; the most effective in

cultivating potato – preparations Energia-M and Mival-Agro, the yield of tubers increased by 9,1 (37 %) and 7,9 t/ha (32 %).

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