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Influence of Diatomite On Crop Productivity.

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ABSTRACT

A part of 15 year research results of studying the possibility to use diatomite (high siliceous rocks) as a fertilizer of crops has been given in the article. Its outstanding performance has been established in cultivation of grain, row and vegetable crops. So, grain productivity of winter wheat when diatomite was applied into the soil in a dose of 3 t/hectare was not inferior to the variant with use of average doses of mineral fertilizers (NPK 40 kg of active substance/hectare), and in case of combined use with urea in a dose of 20 - 40 kg of active substance/hectare – increased by 13 – 28%. In production trials with use of diatomite in a dose of 5 t/hectare productivity of carrots has doubled, of beets has increased by 74%, tomatoes – by 45%. Productivity of sugar beet root crops has increased by 6,4 t/hectare when applying into rows only 40 kg/hectare of diatomite that has provided an additional yield of 2 tons of sugar from each hectare.

Keywords: silicon, high siliceous rocks, diatomite, crops.

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INTRODUCTION

In view of modern requirements to the farming to be organic and ecologically safe the involvement of nonconventional mineral –raw material resources in the sphere of agricultural production which were not considered earlier as fertilizers is becoming more and more important. These are the minerals and rocks possessing unique adsorptive, ion-exchange and catalytic properties. [1] Owing to a mineral structure variety and crystal structure, and also nature of porosity, they have a broad application in the national economy. They also are of great interest for use in the agricultural produce production. It is necessary to refer first of all, the nanostructured high siliceous rocks such as opal - cristobalite (gaize, bergmeals, diatomites) and zeolites to a number of such materials.

From the agronomical point of view the ability to retain them in an arable layer when applying into the soil and to slowly use up moisture, nutrients during vegetation, to create favorable interaction modes in the system "soil – a plant" is important. Besides, they contain a number of nutrients in the structure (potassium, phosphorus, sulfur, manganese and others).

Of them diatomites represent sea sedimentary rocks textured by the smallest opal valves of diatoms. The general porosity of the material reaches 80%, and the size of a pore from 1 to hundreds of nanometers. By 75 – 85% diatomite consists of silicon dioxide. However more than 40% (to 60%) of silicon is in the amorphous form possessing rather high solubility that ensures a possibility of its use as a silicon fertilizer. [2]

Silicon – one of the most widespread elements in the crust also takes the second place after oxygen, composing the majority of the soil minerals. Minerals of the group of quartzes and aluminosilicates are referred to the most widespread of them. [3]

A huge number of works is devoted to studying its role in vital processes in general – and plants in particular in the world and domestic literature. The major conclusion in studying the role and functions of silicon is the conclusion about a possibility of increasing natural resistance of plants to any stresses, that is silicon forms the immune system of plants. [4, 5, 6] It should be noted that mobile silicon (monosilicon acid) in connection with continuous use by crops is a deficient nutrient of plants and microorganisms limiting the productivity of crops (it has been established that its annual total removal is 210 – 224 million tons). [7]

In recent years there has been a growing interest in this element. Large-scale studies on studying the role of silicon in life of plants and efficiency of silicon fertilizers are being conducted in China, the USA, Germany and, especially, Japan. In Japan silicon fertilizers have been included in the register of mineral fertilizers since 1955. The question of necessity to produce silicon fertilizers was raised in our country still in the 70 – 80s of the past century. However they were not produced and have not been produced so far. At the same time Russia has a large source of raw materials various on structure and quality of siliceous rocks, however efficiency of their application as a fertilizer of crops has practically not been studied until the end of the XX century. As a result of more than 15 year researches we have proved high efficiency of high siliceous rocks (diatomite and gaize) as a multifunctional, ecologically safe fertilizer of crops. The results of a part of these studies are given in this article.

Objects, conditions and methods of study

Objects of research were:

- diatomite and gaize of the Inzensky deposit of the Ulyanovsk region with the content of silicon dioxide: general 83,6 and 82,7%, amorphous respectively – 42,0 and 62,8%;
- crops: vegetable – cucumbers, tomatoes, carrots, beetroot, cabbage; grain – winter wheat, spring wheat, barley; row crops – sugar beet, sunflower, corn, potatoes.
- soils: leached chernozem of medium thickness, average clay loam with the humus content of 3,9 - 5,5%, mobile compounds of phosphorus 135 - 160 and potassium of 127 - 155 mg/kg of the soil (according to Chirikov), pHKCl 5,5 - 6,5; typical chernozem of medium thickness, average clay loam with the humus content of 4,5 - 4,7% available P2O5 and K2O respectively 155 - 180 and 115 – 145 mg/kg of the soil, pHKCl 6,0 - 6,8.

In the course of research small - and large plot experiments, and also production trials were conducted with use of high siliceous rocks in cultivation of crops used both in pure form, and together with mineral fertilizers, bird dung and biological products. In total during 2000 - 2015 more than 50 experiments were done (including 10 production trials).

Field and pilot studies have been conducted according to the methodical requirements and state standard specifications. The experimental design has been given in the result discussion section. Replication of field experiments – quadruple with randomized plot design, analytical replication is triple.

The results of a part of these studies concerning the influence of diatomite on crop productivity have been given in the article.

RESEARCH RESULTS

Vegetable crops. Experiments to study influence of diatomite as a silicon fertilizer on yielding capacity of cucumbers, tomatoes, carrots and table beet were performed by us in 2000 - 2004 which showed its outstanding performance, especially in production trials (2002) (table 1)

Table 1 – Influence of diatomite on yielding capacity of vegetable crops, t/ha (experimental-training farm of the Ulyanovsk State Agricultural Academy, the plot area - 5 ha)

Variant	Carrot	Table beet	Tomatoes
Control	13,2	9,6	7,9
diatomite 5 t/ha	26,7	16,7	11,4
$LSD_{0,5}$	3,3	1,0	3,0

Yielding capacity of carrots when diatomite is applied in the soil at a rate of 5 t/ha has doubled, of table beet has risen by 74 %, tomatoes – by 45 %. It should be noted that due to this tomato fructification began by 13 – 15 days earlier, the number of fruits on one plant was by 4 pieces more on average.

Grain crops. Experiments with grain crops have been conducted by us beginning with 2001 up to present time. Yielding capacity values of winter wheat are given in table 2 depending on the diatomite application technology in 2004 – 2006.

Table 2 – Influence of diatomite on yielding capacity of winter wheat, t/ha (experimental field of the Ulyanovsk State Agricultural Academy, accounting area of plots 20 м², the soil – leached chernozem of medium thickness, average clay loam)

Variants	Cropping power, t/ha			
	2004	2005	2006	average
Control	1,83	1,27	2,76	1,95
N40P40K40	2,17	1,47	2,95	2,20
diatomite 3 t/ha	2,28	1,46	2,87	2,20
diatomite 3 t/ha N20	2,47	1,51	3,01	2,33
diatomite 3 t/ha N40	2,68	1,62	3,19	2,50
$LSD_{0,5}$	0,17	0,11	0,35	

First of all, it should be noted that in view of the data for 3 years the use of diatomite in a dose of 3 t/hectare provided the same grain productivity of winter wheat, as average doses of mineral fertilizers (40 kg of active substance/ha of nitrogen, phosphorus and potassium). In case of joint application of diatomite and nitrogen fertilizer (urea) its productivity increased by 13 – 28%. Therefore, application of diatomite in a dose of 3 t/hectare and urea in a dose of 20 - 40 kg of active substance/ha creates the most optimum nutrient conditions for wheat in leached chernozem on macro elements- (including silicon) and trace elements. Average removal of nitrogen by winter wheat in the Central Volga region makes up 3,6 kg/hectare per centner of produce, phosphorus – 1,3 kg, potassium of 2,5 kg. With cropping power of 2 - 2,5 t/hectare their removal from 1 hectare is within limits of 72 - 90 kg of N, 26 – 33 kg of P, 50 – 63 of K. If to take into account that up to one and more than 1 percent of potassium is present in diatomite this provides with these doses (3 – 5 t/hectare) an intake of up to 50 kg/hectare of K2O in the soil, then when using diatomite as a fertilizer the

need of plants in this element is completely satisfied. When it comes to phosphoric fertilizers, the data of experiments confirm the numerous publications data on improvement of phosphoric plant nutrition under the influence of silicon compounds. [8, 9, 10] Besides the need of cereals in phosphorus is lower than in potassium twice, in nitrogen – almost by 3 times much.

Row crops. All experimental row crops (sugar beet, potatoes, corn, sunflower) are high responsive to the application of silicon fertilizers. Yielding capacity of root crops of sugar beet is given in table 3 depending on application of small doses of diatomite (40 kg/hectare in rows at the time of sowing) and diatomite-based silicon complexes of K1 and K2 (for reference: the K1 and K2 complexes were developed at the Institute of fundamental problems of biology of the Russian Academy of Sciences (city of Pushchino) in 2006. They are based on diatomite of the Inzensky deposit, in the first case (K1) – treated with inorganic acids, in the second (K2) – enriched with salts of silicon acid.

Table 3 – Influence of diatomite, diatomite-based silicon complexes on yielding capacity of root crops of sugar beet (t/ha) and sugar recovery from 1 ha (2007 – 2009. USAA experimental field, accounting area of the plot - 48 m²)

Variant	Yielding capacity, t/ha				Sugar content, %	Sugar yield, t/ha
	2007	2008	2009	average		
Control	36,8	22,2	23,8	27,6	18,2	5,0
diatomite 40 kg/ha	46,9	26,1	28,8	34,0	20,6	7,0
Complex K1 40 kg/ha	51,0	26,4	29,9	35,8	20,1	7,2
Complex K2 40 kg/ha	52,5	27,4	28,2	36,0	20,4	7,4
$LSD_{0,5}$	1,0	0,8	0,9		0,1 – 0,2	

The data of the table testify to outstanding performance of silicon fertilizers in cultivation of sugar beet with application of them in small doses locally: the increase of yielding capacity of root crops of sugar beet for 3 years averaged from 6,4 to 8,4 t/hectare, in some years – to 10,1 – 15,7 t/hectare, or it increased by more than 40%.

The application of diatomite and silicon complexes in sugar beet cultivation technology contributed to an increase of not only productivity, but also of the main indicator of product quality – sugar content in root crops. Similar results have been received on all experimental crops.

CONCLUSION

High efficiency of high siliceous rocks as a fertilizer of crops is stipulated by their comprehensive positive impact on properties and soil regimes (agrophysical condition, biological activity, nutritious and water regimes) and in general on the system “soil – plant”. Without focusing in detail on the experimental data in this respect, we will give the main of them:

- application of diatomite into the soil in a pure form (3 and 5 t/hectare) had a structurized and loosening effect on the soil in cultivation of any crops that created a favorable structure of the arable layer. For example, the soil density in the arable layer before sowing spring wheat has decreased from 1,23 to 1,14 g/cm³; before the renewal of winter wheat vegetation – from 1,25 to 1,19 g/cm³;
- diatomite (including through the improvement of agrophysical indicators) favorably influenced the activity of soil organisms: biogenic capacity of the soil increased by 20 – 30% that had a positive effect on its agrochemical indicators. At the same time the content of mineral nitrogen in the arable layer (a dose of diatomite of 5 t/hectare) increased by 16 – 23 mg/kg, available phosphorus by 23 – 52 mg/kg, potassium – by 29 mg/kg.
- application of diatomite into the soil led to a content increase of water-soluble silicon in it by 20% by the time of crop vegetation and 23 – 25% – by the time of their harvesting that promoted optimization of silicon nutrition of plants;
- diatomite substantially ensured a water-retaining capability of leached chernozem, an economical and rational consumption of productive moisture reserves during the vegetation of crops.

Due to the above mentioned it is necessary to recognize that high siliceous rocks make it possible to raise agriculture to a qualitatively new level.

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