

THE FORMATION OF CORN GRAIN YIELD WHEN USING SILICON-CONTAINING PREPARATIONS

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Abstract

Studies to substantiate the species and timing of use of silicon-containing preparations providing the highest productivity of the early ripening hybrid of corn were carried out on heavy loamy leached chernozem. Non-root treatment with NanoSilicon, contributed to an increase in the number of grains in the cob by 13.6-26.7% compared with the control (water treatment), and it was more effective to use the drug in a phase of seven to eight leaves and double treatment. When using Kelik Potassium-Silicon and Microvit-6 Silicon, the number of grains increased by 10.0-19.3%. Double processing with NanoSilicon additionally produced 16.2 g of grain from the ear, which is 28.4% more than in the control. During non-root treatment, Kelik Potassium-Silicon and Microvit-6 Silicon growth compared to the control was 23.3-26.7%. Against the background of foliar treatment with drugs, grain yield increased by 37.5-39.3%, and the best anti-stress effect was achieved by double treatment with NanoSilicon and the use of MicroVit-6 Silicon in the phase of five leaves.

Key words: grain, silicon, corn, structure, productivity.

INTRODUCTION

In modern technologies, great importance is given to various methods of treating plants with environmentally friendly drugs, which stimulate the growth and development of plants, increase their productivity and resistance to stress. In modern agriculture, the search for ways to increase the productivity of agrobiogeocenosis is relevant.

Among the possible ways to solve this problem and increase the profitability of agricultural production, it is of interest to use silicon-containing compounds that not only improve soil fertility, but also have a direct stimulating effect on plants, accelerating their growth and development, as well as increasing resistance to adverse environmental factors.

Silicon is necessary to improve the consumption of nitrogen, phosphorus and potassium. It stimulates growth processes, accelerates the onset of the sweeping and ripening phases, which is associated with an increase in energy for metabolic processes and sugar synthesis.

It was established that plants can absorb low molecular weight silicic acids and their anions not only through the root system, but also

through the surface of the leaves if they are sprayed with silicon-containing solutions.

It is important to note that the absorption of silicon by leaves is about 30-40%, while through the root system it does not exceed 1-5%. In this case, a double cuticular-silicon protective layer forms on the leaf surface (Radkowski et al., 2017).

In addition, silicon accumulation also occurs in the epidermis and conducting tissues of the stem, leaves, roots, and shell of grains (Ma, 2004; Fauteux, 2005; Ma, Yamaji, 2006; Heather et al., 2007).

These accumulations of silicon allow plants to survive under abiotic and biotic stresses (Liang et al., 2007).

One of the important functions of the active forms of silicon is to stimulate the development of the root system (Savithramma et al., 2012; Suriyaprabha et al., 2012; Pavlovskaya et al., 2017).

Of great importance for the country's agro-industrial complex is the willingness to use in its production fertilizer materials obtained using nanotechnology elements. Such substances belong to a new class of modern fertilizers, the fertilizer value of which should be identified first.

The use of silicon-containing preparations in which silicon is in the form of nanoparticles contributes to the greatest assimilation of nutrients by the plant (Gumilar et al., 2017). The best way to make silicon-containing preparations is foliar feeding, which is carried out by spraying with an aqueous solution of fertilizers. When applying this method of feeding, most of the nutrients fall directly on the surface of the leaves of the plant.

In this regard, the study of various types of silicon-containing preparations and the timing of their use in corn crops in the conditions of the forest-steppe of the Middle Volga (Russia) is relevant in the scientific and applied plan, which determined the purpose of the study.

MATERIALS AND METHODS

The experiments were conducted in 2018-2019 under the conditions of the Closed joint-stock Company "Konstantinovo" in the Penza istrict within the Penza region (Russia) on heavy loamy leached chernozem with the following agrochemical characteristics: humus content - 5.1-5.3%; N_{alkali} - 105-112; P_2O_5 - 108-126; K_2O - 148-157 mg/kg of soil; S - 28.8- 29; H_g - 4.6-5.0 mEq/100 g of soil; pH_{HCl} - 5.30-5.41. Field experience was laid down in four repetitions in accordance with generally accepted methods.

We studied the preparations Kelik Potassium-Silicon (1.5 l/ha), Nano Silicon (150 g/ha), Microvit-6 Silicon (0.5 l/ha) and in the control they were treated with water. Non-root treatment was carried out in the phase of 3-5 leaves, 7-8 leaves and double treatment in the phase of 3-5 and 7-8 leaves of corn. The area of the second-order plots is 28 m².

Under the first pre-sowing cultivation, mineral fertilizers were introduced in the norm

$N_{90}P_{60}K_{60}$. The object of research is an early ripe hybrid of corn ROSS 191 MV (FAO 190). Sowing was carried out with aisles of 70 cm. The plant stand density (70 thousand units/ha) was formed in the phase of full germination. The predecessor is winter wheat in pure steam.

An analysis of weather conditions showed that the vegetation of 2018 took place with insufficient moisture supply against a background of moderately low air temperature. The insufficient number of active air temperatures did not contribute to the full realization of the potential of the hybrid and to a high yield of corn grain.

Precipitation during the growing season of 2019 was uneven, but most of it fell in the second decade of July and the first decade of August, during the period of active growth and development of corn, which contributed to the formation of a higher yield of corn compared to the previous year of the study.

RESULTS AND DISCUSSIONS

Two-year studies found that the formation of generative organs was influenced by both the use of preparations containing silicon and weather conditions during the growing season. So, in conditions of insufficient active temperatures and moisture in 2018, in each experiment, one ear per plant was formed.

In a more heat-supplied 2019, an increase in the number of developed cobs was noted with the use of preparations with silicon. On average, over two years of observation during foliar treatment with silicon-containing preparations, the number of developed cobs per 100 plants increased by 13.3-21.8% compared with water treatment (Table 1).

Table 1. Elements of the structure of grain productivity, average for 2018-2019

A drug	Term	Processing number cobs at 100 plants, pieces	Ear			Weight 1000 grains, g
			Length, Cm	Number grains from the ear, pcs	Weight grains from the ear, g	
Nodrug (treatment water)	5 leaves	119	14.8	461	56.9	122
	7-8 leaves	120	14.8	460	57.0	122
	5 leaves + 7-8 leaves	119	15.0	460	57.0	123
Kelik Potassium - Silicon	5 leaves	140	18.3	527	72.1	137
	7-8 leaves	138	17.6	539	65.7	122
	5 leaves + 7-8 leaves	140	19.2	550	70.3	128
NanoSilicon	5 leaves	143	16.9	562	64.6	114
	7-8 leaves	136	18.7	572	65.3	115
	5 leaves + 7-8 leaves	145	19.0	584	73.2	126
Mikrovit-6 Silicon	5 leaves	141	17.5	531	70.4	131
	7-8 leaves	142	17.7	533	65.1	120
	5 leaves + 7-8 leaves	141	19.0	525	68.1	118

The greatest stimulating effect was noted with the use of the drug NanoSilicon. When processing crops in the phase of 5 leaves of corn, the growth of ears per 100 plants amounted to 24 pieces or 20.2% of the option with water treatment. Spraying with NanoSilicon in a phase of 7-8 leaves provided an increase of 13.3%, and double application contributed to an increase in the number of ears of corn by 26 pieces, or 21.8% compared to the version without the drug. Slightly smaller results were obtained with foliar treatment with the Kelik Potassium-Silicon. Spraying in the phase of 5 leaves and binary use of the drug allowed to increase the number of ears of corn by 17.6%, and treatment in the phase of 7-8 leaves - by 15.0%. Treatment with the Mikrovit-6 Silicon preparation on all

experimental variants contributed to an 18.3-18.5% increase in the number of ears of corn per 100 corn plants.

The grain size depends to a certain extent on the linear dimensions of the cob. Measurements showed that on average over the years of research, the length of the ears in variants with silicon-containing preparations increased by 3.2-3.5 cm or 21.5-23.5%. The best results in both years of research were observed on the options for double treatment of plants with preparations with silicon. The increase in the length of the cob was 5 cm. A smaller result was obtained on the application of the drug NanoKremny in the phase of 5 corn leaves - 2.2 cm. On other options, the difference with the variant without the drug was about 3-4 cm.

In 2019, an increase in the length of ears on all versions of leaf processing of corn plants with various preparations with silicon amounted to 1.1-2.8 cm or 7-18%. The best indicators are recorded on the options for the use of Kelik Potassium-Silicon and Nano Silicon preparations in the phase of 7-8 corn leaves and double foliar treatment of plants. In variants with Microvit-6 Silicon, an increase in the length of the cob by 1.4-2.4 cm was noted.

The number of grains in the cob is an important element of the yield structure. It was revealed that in 2018 the use of all preparations with silicon led to an increase in the cob grains. The earliest ones were the cobs during double sheet treatment with NanoKremny. The number of grains in this embodiment was 603 pieces with 396 grains in the variant with water treatment. The use of the Kelik Potassium-Silicon increased the number of grains in the cob by 91-135 pieces, and the maximum increase was obtained on the option with double processing of crops.

Mikrovit-6 Silicon provided an increase in grains in the cob of 40-90 pieces, and the best result was obtained with the use of this drug in the phase of 7-8 corn leaves. In the growing season of 2019, variants with the use of Microvit-6 Silicon were distinguished, which provided an increase in the number of grains of 10.6-15.0%, and the best results were obtained with a double treatment with the drug. NanoSilicon and Kelik Potassium-Silicon showed greater efficiency when using 7-8 corn leaves in the phase, the increase was 114-12.7% compared with water treatment. On average, over two years of experience, more grainy ears were obtained by double treatment with NanoKremny. The addition to the water treatment option was 26.7%.

The use of NanoSilicon in the phase of 5 leaves contributed to an increase in the coarse grains of the ears by 21.7%, and in the phase of 7-8 leaves of corn - by 24.3%. Spraying plants with Kelik Potassium-Silicon in the 5-leaf phase increased the cob grazing by 14.3%. The use of this drug in the phase of 7-8 corn leaves contributed to an increase of 17.4%, and with double treatment, the increase in the number of grains was 19.6%. Processing of Microvit-6 Silicon crops in a phase of 5 leaves led to an increase in cob grazing by 15.2%, in a phase of

7-8 leaves it provided an increase in the number of grains in the cob of 15.9%, and with binary use of the preparation, an increase in grazing was noted, compared to the version with water treatment by 14.1%.

The mass of 1000 grains depends on the performance of the grain and is an indicator characterizing the effectiveness of cultivation techniques. The experimental data obtained indicate that, on average, over two years of the experiment, an increase in the mass of 1000 grains, compared with water treatment, by 7.4% and 12.3% was obtained with the use of Microvit-6 Silicon and Kelik Potassium-Silicon in phase 5 of corn leaves. In other options for improving this indicator of grain quality is not fixed.

Productivity is largely determined by the number of ears of corn on a plant and the weight of grain from one ear. It was established that the most full-bodied ear was obtained by foliar treatment of crops in the five-leaf phase with the preparations Kelik Potassium-Silicon and Microvit-6 Silicon, as well as in the variants with double treatment with NanoKremny and Kelik Potassium-Silicon. The increase in the option with water treatment ranged from 23.3% to 26.7%.

The main quantitative sign of the effectiveness of the applied technological technique is grain yield. The results obtained indicate that the studied preparations showed better adaptogenic properties under the conditions of elevated vegetation temperatures in 2019. The use of NanoKremny in the 5-leaf phase increased grain yield by 2.50 t/ha or 41.7%, and in the 7-8 leaf phase by 2.31 t/ha or 38.8% compared with the version without the drug.

The best result was obtained by double treatment with NanoSilicon, the grain increase was 4.25 t/ha. With foliar treatment of crops with Kelik Potassium-Silicon in a phase of 5 leaves, the yield increased by 3.37 t/ha compared with the version with water treatment, and when using the drug in a phase of 7-8 leaves - by 2.24 t/ha or 38.0%. Against the background of double processing, an additional 2.24 t/ha of grain was obtained. The use of the Microvit-6 Silicon preparation in a phase of 5 leaves and a phase of 7-8 leaves was equivalent and contributed to an increase in grain yield by 3.82 t/ha. Binary treatment with

the drug contributed to an increase in productivity by 3.24 t/ha or 54.4% in relation to the variant with water treatment.

In less favorable conditions for the growing season of 2018, the best results were obtained when processing crops with Kelik Potassium-Silicon. So, foliar treatment in the phase of 5 leaves provided an increase in grain yield of 1.26 t/ha or 40.6% to the variant with spraying with water, and in the phase of 7-8 leaves - 0.87 t/ha or 27.6%. With double treatment with the drug, grain yield increased by 1.37 t/ha or 43.9%. When using NanoSilicon, the yield increase varied from 0.66 t/ha when using the drug in the phase of 7-8 corn leaves, to 1.03 t/ha - in the double-treated version. Leaf treatment in phase 5 of corn leaves with Microvit-6 Silicon increased grain yield by 0.74 t/ha or 23.9% compared with water treatment, in the phase of 7-8 leaves by 0.90 t/ha or 28.6%, and double use 0.83 t/ha or 26.6%.

On average, over two years of observation, the use of the preparation Kelik Potassium-Silicon in the 5-leaf phase contributed to an increase in grain yield by 2.32 t/ha, and in the 7-8 leaf corn phase by 1.56 t/ha or 34.0% compared with water treatment. When spraying twice, the increase was 1.80 t/ha. The use of NanoSilicon in the phase of 5 corn leaves made it possible to obtain an additional 1.62 t/ha of grain or 35.7% in relation to the variant with water. The foliar treatment of crops in the phase of 7-8 corn leaves ensured an increase in grain yield by 1.49 t/ha and double treatment by 2.64 t/ha. In the variant with treatment with Mikrovit-6 Silicon in a phase of 5 leaves, the grain yield growth was 2.28 t/ha or 50.2%, and in a phase of 7-8 leaves and when applied twice, the increase was 43.0% of the variants with water treatment.

CONCLUSIONS

During the foliar treatment with silicon-containing preparations, the number of developed cobs per 100 plants increased by 13.3-21.8% compared with the treatment with water, and the greatest stimulating effect was noted with the use of the drug Nano Silicon.

More blackened ears were obtained by double sheet treatment with NanoKremny; the addition to the variant with water was 26.7%. During

foliar treatment, Kelik Potassium-Silicon Mikrovit-6 Silicon, the cob gravel content increased by 14.1-17.4%.

During leaf treatment of crops in the five-leaf phase with Kelik Potassium-Silicon and Microvit-6 Silicon preparations, as well as in variants with double treatment with NanoKremny and Kelik Potassium-Silicon, the grain weight from the ear increased by 23.3-26.7%.

Against the background of foliar treatment with drugs, grain yield increased by 34.0-51.1%, and the best anti-stress effect was achieved by double treatment with NanoSilicon and the use of MicroVit-6 Silicon and Kelik Potassium-Silicon in the phase of five corn leaves.

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