International Journal of Multidiscipline

TLEP – International Journal of Multidiscipline
(Technology, Language, Education, and Psychology)
ISSN: 2488-9342 (Print) | 2488-9334 (Online)

Open Access | Peer-Reviewed | Monthly Publication | Impact factor: 8.497 / 2025

The Effect Of Stimulants And Silicon Complex Fertilizers On The Yield Of Soybean Varieties

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ABSTRACT
This article presents data on the effect of stimulants and silicon complex fertilizers on the yield of soybean varieties and their analysis. According to it, it was found that stimulants and silicon complex fertilizers affected the yield of soybean varieties. The use of stimulants and silicon-based fertilizers and their combined use in a complex manner led to an increase in yield. Good results were recorded when using the Maltamin stimulant (3.5 l/ha), Sila silicon fertilizer (450 ml/ha), and Fon +Sila silicon + Maltamin (450 ml/ha+3.5 l/ha) as foliar feeding.
Keywords: soybean, variety, Nafis, Vilana, fertilizers, stimulants, Uzbiogumin, Regoplant, Maltamin, Sila silicon, yield.

INTRODUCTION

In our republic, in recent years, it is important to make good use of areas that have been harvested from grain crops, to grow a second crop, to increase soil fertility, to grow high-quality valuable grain crops, including soybean, and to produce a high yield with the effective use of regional bioclimatic resources.

Soybean crop among legumes is a valuable crop to increase soil fertility that accumulates a lot of nitrogen during the season, and has a lot of protein and oil in its seeds (2, 5).

The soil and climatic conditions of Uzbekistan provide an opportunity to plant and harvest several different crops per year, with the effective use of irrigated land. The high temperature that lasts from mid-May to the end of September is very favorable for the growth of heat-loving crops (soybeans, mung beans, etc.) and grain formation (4, 5).

Soybean is a biologically clean crop that improves soil structure and activates biological processes. Analysis shows that 0.65-0.72% humus in the soil before soybean planting reaches 0.95-1.03% after soybean planting (4).

In recent years, in addition to organic, mineral and green fertilizers, bacterial fertilizers and inoculants have been widely used in agriculture to increase the yield of leguminous crops, including soybean has taken research results in various sources on how to make, collect, absorb, satisfy the plant's need for nitrogen up to 50-70% and increase soil fertility, improve water-physical properties, drastically reduce the use of nitrogen fertilizers (7, 8, 9, 10, 11, 12).

Kh.N. Atabaeva., F.B. Namozov., A.A. Kurbanov and S.Sh. Khayrullaev in their experiments conducted in 2018-2020, when they applied micronutrients to the soybean crop, micronutrients affected the height of the soybean stem, leaf, root development, nodule formation, grain quality and productivity, and provided a high yield [10].

According to R. Jo'raeva., J. Toshpol'atov., A. Iminov., Kh. Bozorov and L. Zaynitdinova, S. Khatamov and S. Sh. Khayrullaev, in their experiments conducted in 2015-2017, soybean plant mineral fertilizers and belonging to the rhizobium group it was observed that the yield increased by 12.6-12.8 q/ha when exposed to azotobacteria strains compared to the control variant [11, 14].

According to Khayrullayev Sardor Shamsiddin ugli (2021), the application of micronutrients in the suspension method 2 times during the application period of soybean varieties in the conditions of meadow-swamp soils provides an increase in grain quality [16]. According to data of Atabayeva Khalima Nazarovna, Khayrullaev Sardor Shamsiddin o'g'li, and Usmonova Shohista Usmon qizi (2020), sulfur has a positive effect on the branching of soybean varieties on the background of mineral fertilizers, and in 2018 the number of branches in the variety "Orzu" increased by 0.8-1.3 compared to the control option due to the micro element sulfur. In the "Nafis" variety, this figure was 0.3-0.4, and good results were obtained from medium and high sulfur standards. In 2019, these indicators increased by 0.3-0.7 in the variants of sulfur compared to the control in the "Orzu" variety, increased by 0.1-0.3 in the "Nafis" variety, and good results were obtained from the medium and high standards of sulfur [13]. According to Iminov Abduvali Abdumannobovich, Khayrullayev Sardor Shamsiddin ugli, et al, Nitragine treatment of soybean and mung bean seeds before sowing had a positive effect on seed germination under both laboratory and field conditions, the germination rate of seeds in the laboratory under the conditions of cotton cultivation in the following year under the background of non-treatment by nitragine before sowing the seeds of soybean and mungbean crops grown as a secondary crop after winter wheat was 0.3-1.3%, and field fertility was 0.2-0.8% higher. Also, it was found that the use of phosphorus and potassium fertilizers in soybean and mung bean crops grown as a secondary crop was 0.6-1.0% higher in the laboratory, and 0.6-0.7% higher in the field than in the control options without mineral fertilizers in studies [12]. According to Umarova Nigora Sadriddinovna, Bo'riboyev Bekzod Yetmish ugli, Khayrullayev Sardor Shamsiddin ugli, Usmonova Shokhista Usmon kizi, & Turdaliyeva Shokhista Tulkinjon kizi, the demand of the soybean plant for mineral fertilizers, it was observed that when NPK and liquid fertilizer were used together, all the biometric parameters and yields of the plant increased by varieties compared to other methods. The use of mineral fertilizers in different ways in typical sierozem soil conditions affects the grain yield of local and foreign varieties. In other words, the average yield of medium-ripe soybean varieties "Nafis" was 43.4 c / ha, "Vilana" was 42.4 c / ha, and the best way to increase the yield is to apply fertilizers as NPK in combination with liquid fertilizer [17]. According to data of Khayrullayev Sardor Shamsiddin o'g'li and Usmonova Shohista Usmon qizi, the location of the lower first pod in soybean varieties is 12.8-15.9 cm in Orzu variety, 3-3.1 cm in Radimax stimulator, 2.2-2.4 cm in Gummat stimulator, 2.1 cm in Tecamin stimulator and 3.1 cm in Algora stimulator was found to be high. The most effective results were observed in Radimax, Gummat and Algora bio-simulators, and the location of the lower first pod was detected 14.7-17.6 cm in the "Nafis" variety, which was 2.5-2.9 cm higher in the Radimax stimulator, 2.2-2.5 cm higher in the Gummat stimulator, 2.1 cm higher in the Tecamine stimulator, and 2.4 cm higher in the Algora stimulator than in the control variant. The most effective results were observed in Radimax, Gummat and Algora biosimulators [15]. According to Atabayeva, K. N., Umarova, N. S., Yakubov, S., & Khayrullaev, S. S, positive results were obtained from moderate levels of sulphur and manganese, and low levels of iron. Macro and micronutrients had a positive effect on soy yield. An additional 7.6 quintals (q)/ha was harvested in exchange for macro fertilizer. Compared to the background variant, the yield was 4.6-8.3 q/ha for sulphur and 4.9-9.8 q/ha for manganese. The yield of the iron element

was lower than that of the background variant. Grain quality has changed in exchange for macro and micronutrients. In exchange for mineral fertilizers, this figure increased by 2.4%. In exchange for the element sulphur, the protein increased by 3.1-5.8%; an increase of 4.4-8.4% was observed in exchange for the element manganese. It was noted that the protein increased by 7.9-8.7% in exchange for the element iron [18]. Khayrullayev, S. S., & Kizi Usmonova, S. U explained that mineral fertilizers and sulfur microelements activate the symbiotic activity of soybean variety "Orzu", averaging 32.4-42.3 million nodules per hectare, the number of nodules due to the background of mineral fertilizers increased by 13.6%, and there was an increase of 19.4-23,4% due to sulfur, as well as an average weight of nodules was 6.46-9.56 c / ha, the weight of nodules increased by 5.3% due to mineral fertilizers, and 17.1-32.4% due to sulfur. During the application period, 6.46-9.56 c / ha of nodules mass was accumulated per hectare according to the studied variants, which contributes to the increase of nitrogen and organic matter in the soil and a slight increase in biological efficiency [19]. Usmonova Sh.U, Khayrullaev S.Sh, Shomuqimov N.N, & Gaynanova A.F, said that the influence of stimulants on soybeans affected the weight of 1000 grains of Vilana cultivar, under the influence of Gummat stimulator this figure was 2.2-7.4 grams higher than on basis of mineral fertilizers (Background), and under the influence of Rival stimulator-3.0-6.0 grams [20]. According to Khayrullaev S. S, In the variant, where not used mineral fertilizers and micronutrients, the leaf area in the control variant of the Orzu variety of soybean was 51.1 thousand m^2 / ha. Under the influence of microelements, the leaf area of Orzu was 59.1-64.6 thousand m^2 / ha. The highest rates of exposure to micronutrients were observed with medium use of sulfur and manganese. Under influence macro and micro fertilizers, the leaf area of Orzu variety increased from 4.0 to 13.5 thousand m^2 / ha, or from 7.3 to 20.9% [21].

It was found that when the plants were exposed to urea at different rates, they had an effect on their biometric indicators, and when the urea rate was increased to 15 grams, all biometric indicators were better than other options (Umarova Nigora Sadriddinovna, et.al. 2023) [22]. The application of stimulants to plants increases their resistance to abiotic factors. All the stimulators in the experiment showed their effect for the preservation of the plant, and the foliar feeding variant of the fulvogummat stimulator showed a better result than the other stimulators (Usmonova Shokhista Usman kizi, et.al. 2023) [23].

Usmonova Shokhista and other scientists noticed that the growth process has a great role in the formation of the plant's fruit, and the use of stimulants in the experiment showed a positive effect on the growth process of the plant. The studied stimulators have an effect on the growth process, among the stimulators Fulvogummat stimulator was 164.9 cm tall when fed from the leaf, and recorded a good indicator among the variants (Usmonova Shokhista Usman kizi and et.al. 2023) [24].

MATERIALS AND METHODS

Place and conditions of experiment. The experiments were conducted in the experimental fields of Tashkent State Agrarian University. In this case, the experimental variants were in 4 repetitions for each variety, the number of variants was 10, the number of plots was 40, the length of each plot was 10 m, the width was 2.8 m. The variants were placed in a randomized method. Each option had 4 rows, and the total area of each plot was 28.0 m^2, of which 2 rows in the middle were designated as counting rows, and 2 rows on the edge were designated as protection rows. The number

of counting plants was 20. The experiments were carried out in field and laboratory conditions.

The experiments were carried out in the field and laboratory methods. The experiments were carried out using the methods of “Methods of conducting field experiments” (UzPITI), “Methodology of field experiments” (B. Dospekhov), “Methodology of State variety testing of agricultural crops”, “Methods of agrochemical, agrophysical studies of the soil of Central Asia”, leaf surface Nichiporovich (weight method), number and weight of nodes G.S.Posipanov. The field experimental systems of the conducted dissertation research were carried out as follows (see Table 1).

Varieties which used in the experiment

Nafis variety. The variety was created by the method of individual selection at the Rice Research Institute of Uzbekistan.

The growing period is 115-120 days. The height of the plant is 145-150 cm. The location of the lower pod is 14-16 cm, the number of branches is 2-4, the number of pods in one plant is 120-130, the number of grains in one pod is 2-4.

Grain quality and technological parameters: weight of 1000 seeds is 165-175 g. The protein content of grain is 40-41%, the oil content is 25-27%. Resistant to lodging, shedding, diseases and mechanized harvesting.

Yield: 30-32 q/ha grain yield and 250-300 q/ha blue mass can be obtained from the variety under favorable conditions.

Vilana variety: The variety was created at the All-Russian Research Institute of Oil crops. This variety was obtained by cross-breeding the L-309 hybrid generation with the 0240 collection sample and individual and mass selection in the F_2 and F_3 varieties. The plant hairs are gray. The flowers are purple, the pods are brown, the seeds are yellow, dull, without spots. The variety is mid-ripening, resistant to adverse conditions, drought-resistant, and yields increase when watered. The growing season is 116-120 days. Seed yield without irrigation is 32-34 q/ha, and with irrigation up to 42 q/ha. Plant height is 111-115 cm, the lower pod location is 16-17 cm. The protein content in the grain is 40.1-40.3%, the oil content is 22.4-22.6%.

Uzbiogumin Stimulator. A natural biostimulant for plant growth and development, ensuring high yields and healthy plants. UzBioGumin specialized production technology, based on the latest scientific advances, extracts and preserves the full range of biologically active substances created by nature itself: humic and fulvic acids, macro- and microelements in the form of bioavailable organic compounds, and beneficial microflora.

Composition: Humic acids at least 20 g/l. Total nitrogen (N) content is 1.2%. Water-soluble phosphorus (R2O5) 1.9%. Water-soluble potassium (K_2O) 8.3%. Microelements: Soil, Fe, Cu, Mn, Mo, Mg, N, P, K, Ca, and Zn.

Maltamin Stimulator. Maltamin is a plant growth regulator with growth-promoting properties, obtained from malt sprouts. This product is intended for use in growing grains and legumes. It increases seed germination and vigour, accelerates the plant's progression through the main stages of development, enhances root and aerial development, increases yields, and improves the quality of finished products (protein, starch, and vitamin content, and reduces nitrate levels). Ingredients: melanoidins 42.0-56.0 g/l, amino acids 5.5-7.4 g/l, low molecular weight carboxylic acids 7.3-9.8 g/l, pectins 0.9-1.2 g/l, phenolic carboxylic acids 0.5-0.7 g/l, sodium sulfate 68.0-75.0 g/l, sodium hydroxide 12.0-15.0 g/l, and water.

Regoplant Stimulator. Regoplant is a plant biostimulant from a series of composite products. Its action is based on the synergistic interaction of products from

the biotechnological cultivation of micromycete fungi from the ginseng root system and avermectin. The product also includes a biopreparation with antiparasitic action. It is a balanced composition of biologically active compounds—analogues of phytohormones, amino acids, fatty acids, oligosaccharides, chitosan, and microelements—as well as bioprotective compounds. Composition: Complex of biologically active compounds - waste products of micromycete fungi - 0.3 g/l (saturated and unsaturated fatty acids (C 14 -C 28), polysaccharides, 15 amino acids, analogs of phytohormones of cytokine and auxin nature)

Complex of biogenic microelements - 1.75 g/l, in particular: B 3+ - 0.23 g/l, Cu 2+ - 0.26 g/l, Mn 2+ - 0.2 g/l, Zn 2+ - 0.32 g/l, Co 2+ - 0.14 g/l, Fe 2+ - 0.5 g/l, Mo 6+ - 0.1 g/l, Potassium salt of alpha-naphthylacetic acid - 1 mg/l, Aversetin C - waste product of the actomycete Streptomyces aarmytilis - 0.01 g/l.

Sila Silicon complex fertilizer. The Sila Silicon complex fertilizer is a new type of modern fertilizer, a broad-spectrum antidote that helps crops better absorb micronutrients and become more resistant to diseases and pests. It helps increase yields, restore soil fertility, and remove radionuclides. The product consists of a mixture of nanopowders of silicon (nano-silicon), iron, zinc, copper, calcium, magnesium, sulfur, and other elements, placed in a polyethylene glycol medium to prevent oxidation. The active silicon content in the product is 50-60 percent. The silicon particles are nano-sized, making them easily absorbed by plants at the cellular level. Silicon nanoparticles not absorbed by plants, as well as the portion of the product not applied to plants, quickly turn into ordinary sand due to oxidation under the influence of oxygen and water. Using the "SILA SILICON" mineral complex results in accelerated seed germination, a shorter plant growth cycle, a significant increase in yield and product quality, longer shelf life, and increased plant resistance to adverse growing conditions, which is especially important for risky farming areas. The product can revive plants damaged by frost.

Phenological observations were made during the periods of budding, tillering, flowering, podding and ripening. These observations were made on plants counted in all replicates. In all experiments, the development periods and their duration were determined by variants.

Before harvesting, biometric measurements were taken on the counted plants. The counted plants were analyzed in 4 replicates: for this, the counted plants were separated from the plots separately by variant and replicate, and their stem height, number of branches, height of the lower first pod, number of pods and grains, pod and grain weight, grain yield (%), hay mass and 1000 grain weight were determined. To determine the 1000 grain weight, 1000 seed samples were counted, weighed and the average indicator was determined. The yield of soybean varieties was determined. For this, the pods of the plants in the counted rows were collected in the plots, threshed and the grain weight was determined. The yield was determined when the yield in the plot was converted into hectares using the number of bushes.

Statistical analysis of the obtained data was carried out using the Microsoft Excel program and the method of B.A.Dospekhov's “Method of field experiments” (B.Dospekhov, 1985, 2012);

RESULTS AND DISCUSSION

Stimulants and silicon complex fertilizers have a positive effect on the growth, development and biometric indicators of soybeans, as well as on increasing crop yield. In 2023-2025, the yield of the Nafis variety when applied without fertilizer will be 18.6-20.0-19.0 t/ha, depending on the year; When using mineral fertilizers, it was 28.2-

29.9-28.9 q/ha, and when using mineral fertilizers together with water, it was 28.4-30.2-29.1 q/ha. When using Uzbiogumin, Regoplant, and Maltamin stimulants, the Maltamin stimulant showed better results than other stimulants, 14.1-14.8-14.1 q/ha or 75.8-74.0-74.2% compared to the one used without fertilizers, 4.5-4.9-1.8 q/ha or 15.9-16.4-6.2% compared to the one used with mineral fertilizers, and 4.0-4.6-4.0 q/ha or 15.9-16.4-6.2% compared to the one used with mineral fertilizers. Increased by 14.1-15.2-13.7%. When using complex silicon fertilizer, the yield increased by 14.6-15.3-14.6 q/ha or 78.5-76.5-76.8% compared to the case without fertilizer, by 5.0-5.4-4.7 q/ha or 17.7-18.1-16.3% compared to the case with mineral fertilizers, and by 4.8-5.1-4.5 q/ha or 15.3-16.9-15.5% compared to the case with mineral fertilizers combined with water. When using the silicon complex fertilizer in combination with Uzbiogumin, Regoplant and Maltamin stimulants, the highest yield was achieved when using the Maltamin stimulant, increasing by 16.1-16.8-16.0 q/ha or 86.5-84.0-84.2% compared to the case without fertilizer, by 6.5-6.9-6.1 q/ha or 22.8-23.1-21.1% compared to the case with mineral fertilizers, and by 6.3-6.6-5.9 q/ha or 22.1-21.8-20.3% compared to the case with mineral fertilizers and water. Based on average 3-year data, the yield of the Nafis variety when used without fertilizer was 19.2 q/ha; When using mineral fertilizers, it was 29.0 q/ha and when using mineral fertilizers together with water, it was 29.2 q/ha. When using Uzbiogumin, Regoplant and Maltamin stimulants, the Maltamin stimulant showed better results than other stimulants, increasing by 14.3 q/ha or 74.5% compared to the case without fertilizers, by 4.5 q/ha or 15.5% compared to the case with mineral fertilizers, and by 4.3 q/ha or 14.7% compared to the case with mineral fertilizers together with water. When using complex silicon fertilizer, the yield increased by 14.8 q/ha or 77.1% compared to the application without fertilizer, by 5.0 q/ha or 17.2% compared to the application of mineral fertilizers, and by 4.8 q/ha or 16.4% compared to the application of mineral fertilizers in combination with water. When using the silicon complex fertilizer in combination with the stimulants Uzbiogumin, Regoplant and Maltamin, the yield increased by 16.3 q/ha or 84.9% compared to the application without fertilizer, by 6.5 q/ha or 22.4% compared to the application of mineral fertilizers, and by 6.3 q/ha or 21.6% compared to the application of mineral fertilizers in combination with water.

Table 1. The effect of stimulants and silicon complex fertilizers on the yield of soybean varieties, q/ha (2023-2025)

Application norms of stimulants and complex silicon fertilizers	Yield, q/ha			
	2023	**2024**	**2025**	**Average**
Nafis				
Control (without fertilizer)	18.6	20.0	19.0	19.2
Background - (N-60, P-120, K-80 kg/ha)	28.2	29.9	28.9	29.0
Background - (N-60, P-120, K-80 kg/ha)+suv	28.4	30.2	29.1	29.2
Background +Uzbiogumin (1.8 l/ha)	31.3	34.2	33.2	32.9
Background +Regoplant (150 ml/ha)	32.0	34.0	30.7	32.2
Background +Maltamin (3.5 l/ha)	32.7	34.8	33.1	33.5
Background +Sila kremniya (450 ml/ha)	33.2	35.3	33.6	34.0

Background +Sila kremniya+ Uzbiogumin (450 ml/ha+1.8 l/ha)	33.6	35.7	34.0	34.4
Background +Sila kremniya+ Regoplant (450 ml/ha+150 ml/ha)	33.8	35.9	34.2	34.6
Background +Sila kremniya+ Maltamin (450 ml/ha+3.5 l/ha)	34.7	36.8	35.0	35.5
Vilana				
Control (without fertilizer)	16.5	17.8	16.9	17.1
Background - (N-60, P-120, K-80 kg/ha)	25.1	26.6	25.7	25.8
Background - (N-60, P-120, K-80 kg/ha)+suv	25.3	26.8	25.9	26.0
Background +Uzbiogumin (1.8 l/ha)	27.9	30.4	29.5	29.3
Background +Regoplant (150 ml/ha)	28.5	30.3	27.3	28.7
Background +Maltamin (3.5 l/ha)	29.1	31.0	29.5	29.9
Background +Sila kremniya (450 ml/ha)	29.5	31.4	29.9	30.3
Background +Sila kremniya+ Uzbiogumin (450 ml/ha+1.8 l/ha)	29.9	31.8	30.2	30.7
Background +Sila kremniya+ Regoplant (450 ml/ha+150 ml/ha)	30.1	32.0	30.4	30.8
Background +Sila kremniya+ Maltamin (450 ml/ha+3.5 l/ha)	30.8	32.8	31.2	31.6

In 2023-2025, the yield of the Vilana variety without fertilizer will be 16.5-17.8-16.9 tonq/ha, depending on the year; When using mineral fertilizers, it was 25.1-26.6-25.7 q/ha and when using mineral fertilizers together with water, it was 25.3-26.8-25.9 q/ha. When using Uzbiogumin, Regoplant and Maltamin stimulants, the Maltamin stimulant showed better results than other stimulants, 12.6-13.2-12.6 q/ha or 76.4-74.2-74.6% compared to the one used without fertilizers, 4.0-4.4-3.8 q/ha or 15.9-16.5-14.8% compared to the one used with mineral fertilizers and 3.8-4.2-3.6 q/ha or 15.9-16.5-14.8% compared to the one used with mineral fertilizers and Increased by 15.0-15.7-13.9%. When using complex silicon fertilizer, the yield increased by 13.0-13.6-13.0 q/ha or 78.8-76.4-76.9% compared to the case without fertilizer, by 4.4-4.8-4.2 q/ha or 17.5-18.0-16.3% compared to the case with mineral fertilizers, and by 4.2-4.3-4.0 q/ha or 16.6-16.0-15.4% compared to the case with mineral fertilizers combined with water. When using the silicon complex fertilizer in combination with Uzbiogumin, Regoplant and Maltamin stimulants, the highest yield was achieved when using the Maltamin stimulant, increasing by 14.3-15.0-14.3 q/ha or 86.6-84.3-84.6% compared to the case without fertilizer, by 5.7-6.2-5.5 q/ha or 22.7-23.3-21.4% compared to the case with mineral fertilizers, and by 5.5-6.0-5.3 q/ha or 21.7-22.4-20.5% compared to the case with mineral fertilizers and water.

Based on average 3-year data, the yield of the Vilana variety when used without fertilizer was 17.1 q/ha; When using mineral fertilizers, it was 25.8 q/ha and when using mineral fertilizers together with water, it was 26.0 q/ha. When using Uzbiogumin, Regoplant and Maltamin stimulants, the Maltamin stimulant showed better results

than other stimulants, increasing by 12.8 q/ha or 74.8% compared to the case without fertilizers, by 4.1 q/ha or 15.9% compared to the case with mineral fertilizers, and by 3.9 q/ha or 15.0% compared to the case with mineral fertilizers together with water. When using complex silicon fertilizer, the yield increased by 13.2 q/ha or 77.2% compared to the application without fertilizer, by 4.5 q/ha or 17.4% compared to the application of mineral fertilizers, and by 4.3 q/ha or 16.5% compared to the application of mineral fertilizers in combination with water. When using the silicon complex fertilizer in combination with the stimulants Uzbiogumin, Regoplant and Maltamin, the yield increased by 14.5 q/ha or 85.8% compared to the application without fertilizer, by 5.8 q/ha or 18.4% compared to the application of mineral fertilizers, and by 5.6 q/ha or 21.5% compared to the application of mineral fertilizers in combination with water.

CONCLUSION

In conclusion, the use of stimulants and silicon-based fertilizers and their combined use in a complex manner led to an increase in yield. Good results were recorded when using the Maltamin stimulant (3.5 l/ha), Sila silicon fertilizer (450 ml/ha), and Fon +Sila silicon + Maltamin (450 ml/ha+3.5 l/ha) as foliar feeding.

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