The effect of fertilizers containing silicon on the yield of tomatoes and cucumbers

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Abstract. The effect of preparations containing silicon: seliplant nanosilicon, Bona Forte biostimulator and sodium silicate on growth, development and yield was studied on hybrids of cucumber Pierre F_1 and tomato Merlis F_1. Studies have shown that when tomatoes are fed under the root, the product matures early and yields increase by 6.5-8.0 kg/ m^2, and this indicator is due to an increase in the number of fruits (by 10-12%), and the average fruit weight increased by 18-23%. As a result of the use of silicon-containing fertilizers in the cultivation of cucumbers, an increase in the area of assimilation, an increase in the number and weight of the formed fruits was observed. Productivity and product quality increase, as well as the amount of dry substance increases and the amount of nitrates in products decreases, that is, it decreases from 382 mg/kg to 181-230 mg/kg. The reason for the maximum increase in cucumber yield by 5.3-6.5 kg/m^2 was observed as a result of the use of bio stimulants containing seliplant and silicon.

1 Introduction

One of the most important tasks of vegetable growing is to provide the population with fresh vegetable products throughout the year. We think that solving this issue is only from expanding arable land and increasing the productivity of agricultural crops [22-34].

According to the Department of Statistics of Uzbekistan from 2015 to 2024 years, the increase in Uzbekistan by 45% amounted to 45.2 thousand hectares. The self-sufficiency of the population with vegetables rose from 625% to 92.3%. Vegetables in greenhouses increased by 0.5 million to 2.8 million tons [4, 10, 19].

Compared to the volume of production, a 1hectares of greenhouse replaces a 10-20 hectares of open field yield [11, 18].

In order to obtain a high yield, chemialization is carried out by complex use of means, the cultivation of agricultural products using intensive technology, as well as the application of hydroponics. The fertilizer application system emphasizes basic macronutrients (N, P, K, Fe) and microelements (Mn, Zn, B, Cu, Mo, Co), macronutrients in greenhouse conditions (S, Ca, Mg) as well as microelement Silicon (Si) are considered conditionally necessary. Their amount is 10% of the dry mass in plants.

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In foreign literature, many scientific works have shown a positive effect on the formation of crop yields of agricultural crops under the influence of silicon, observed primarily in cereal crops [1,14,15].

When growing vegetable crops, there are solutions about the effectiveness of Silicon-containing fertilizers [2,9,12]. But the mechanism of the effect of this element on plants has not been sufficiently studied. It has been suggested that silicon plays a special role in its resistance to biogenic and abiogenic stresses and external unfavorable factors [3,6,17,21].

Some authors suggest that the increase in the absorption of basic nutrient elements (N, P, K) has a large contribution of silicon-containing preparations [13,16].

Since in nature this element is widespread and is present in large quantities in the soil, and its transition to growths is in very small quantities, it is better to improve the yield and its quality through the use of all kinds of silicon-containing preparations.

Depending on the composition and methods of application, a wide range of mineral fertilizers is distinguished into: Silicon-containing meliorant (e.g., ceolites, diatolites, etc.) they are applied in large quantities to the soil; seeds are treated before planting and during feeding (they are treated with natrium and potassium silicates, amorphous SiO_2, etc.) Silicon-containing bio-stimulants during the growing season [5,6,7,8,20].

The effect of the preparations was studied in the cultivation of cucumbers and tomatoes in greenhouse conditions.

2 Materials and Methods

The effect of silicon-containing preparations on the yield of cucumbers and tomatoes was studied in the educational experimental Agricultural Greenhouse of Tashkent State Agrarian University.

As an object of research, the preparations of cucumbers parthenocarpic Hydra ber F_1 and tomato Merlis F_1 were taken.

The growing was carried out in mineral cotton by the hydroponics method. The size of the fabric is 15x100 cm, in each mat 5 plants were placed, the thickness of the plant's cucumbers 2.4 Pcs/m^2. The experiment was carried out with 4 repetitions. The composition of feed solutions, in all experiments, is the only background, which is presented in the Table 1 (Table 1). The amount of microelement in solution was determined in mc mol/l: Fe-15 Mc mol/l; Mn-10; B-30; Cu-0.75; Mo-0.5;

Pickling tomato indicators on May 15, replacing seedlings on May 26, placing seedlings on the mat on June 9, seeds of cucumbers are transferred to the mat on October 20, November 17. During the vegetation, 4 times were treated with non-root silicon-holding preparations: Nano Silicon (20% Si+Fe,Cu,Zn) siliplant (7% Si+K, Mg, Fe, B, Cu, Zn, Mn, Co), growth biostimulator Bona Forte (7.5% Si+ Juniper cotton extract).

One-sided quality silicon fertilizer was used, based on the recommendations of the manufacturers, silicon was used in an equivalent amount (300mt Si/l). 1 processing in the phase of the formation of 23 true leaves, at an interval of 2 weeks after laying the cubes, the processing was sprayed.

Table 1. Composition of food solutions

Development phase	$N\text{-}NO_3$	P	S	N-NH4	K	Ca	Mg	EC msm/cm
Tomat								
Watering the seedling	13,55	1,55	3,90	1,25	3,75	4,15	2,00	1,8-3,0
Drink mats	13,55	1,50	4,00	1,00	5,25	5,15	3,00	2,8
1- up to the	13,65	1,45	3,90	1,25	8,75	4,15	2,00	2,8

beginning								
1-3 heads	14,75	1,45	3,36	0,60	7,75	4,05	2,50	2,8
3-5 heads	14,20	2,25	4,28	1,50	9,00	4,30	2,05	3,0
5-10 heads	14,00	2,05	4,13	1,00	9,00	4,50	1,75	2,9
Cucumber								
Watering the seedling	16,00	1,45	1,53	1,25	8,00	3,90	1,38	1,82,7
Drink mats	16,00	1,45	1,53	0,85	5,50	4,60	2,13	2,5
4-6 weeks	16,00	1,45	1,53	1,25	7,00	4,40	1,38	2,5
To bear fruit on the ground	18,70	1,82	1,95	0,94	9,90	4,85	1,84	2,5

Composition of nutrient solutions. During the period of research in the greenhouse, the main microclimate conditions are presented in the table below (Table 2). Illumination is the main factor affecting productivity. According to the results obtained, it was observed that the energy of the falling Sun increased by 329% from the annual medium indicator. During the period of growing cucumbers, it was observed that the air humidity deviated from the norm, as well as the temperature was below the optimal level. The amount of CO_2 in the air was kept at the level of 800-900 P pm.

Analysis of the chemical composition of plant samples was determined in generally accepted ways. The amount of dry substance is thermogravimetric; the amount of sugars is refractometric;

The composition of the element was determined in ash: in the nitrogen-Keldal micro-method; in the phosphorus-photometric method; in the potassium-flame photometry method; the results of the experiment were determined in MS-Excel in the statistical method of single-factor dispersion analysis.

Table 2. Microclimate conditions in the greenhouse during the period of research (average monthly indicators)

Month	**Air temperature, °C**	**Air humidity, %**	**Solar energy Dj/cm2**
Tomato			
July	21,3	76	1982
August	22,2	75	1808
September	20,3	75	866
October	21,3	67	474
Cucumber			
November	21,4	60	152
December	20,6	71	109
January	20,2	70	130
February	21,2	73	381

3 Results and Discussion

Effect of silicon-containing preparations on the yield of tomatoes. The calculation of morphobiometric indicators shows that the use of silicon-containing preparations enhances the growth of tomato at the initial stages of its development.

The reason that the biostimulator Bona Forte has a strong effect is due to the presence of triterpenic acids in its composition. During the period from planting to fruiting, growth in relation to control increased by an average of 10%. Alternatively, when observed over a period of one month, the difference in fruit formation with growth in plants decreased from

22% to 6%. The following indicators have also been observed when treated with triterpene acids in open field conditions.

The application of silicon ensured premature ripening of the crop. In the intermediate control option, the first harvest was collected 5 days late. So, in comparison with the control, an additional 1.2-1.6 kg/m2 product was collected in the yield of the silicon-treated variant in the first week.

An additional harvest was obtained by applying silicon for 3 months when statistical processing was carried out to the results of the experiment. Here, one-month fruit matured prematurely due to the strong effect during the fruiting period (Table 3).

In August, the yield of tomatoes increased by 65-70% compared to control in silicon-treated variants. In September, the effect of all silicon-containing preparations on tomato yield was the same, with an increase of 30-35% compared to control. In October, this indicator decreased by 10-16%.

Table 3. Formation of a tomato crop as a result of the use of silicon-containing preparations

Option	Productivity kg/m2			Number of fruits/m2			Average fruit mass (g)		
	1	2	3	1	2	3	1	2	3
Control	4,9	8,2	9,3	38	62	60	123	132	155
Nano silicon	8,3	10,8	10,9	50	66	63	168	166	170
Siliplant	7,8	10,5	10,2	49	65	62	159	163	164
Biostimulant	8,5	10,7	10,4	50	63	64	169	170	162
Sodium silicate	8,1	10,8	10,5	49	65	63	166	165	167
NSR-05	0,5	0,5	0,4	3	4	3	2	3	2
r	-	-	-	0,47	0,69	0,84	0,98	0,92	0,82

As can be seen from Table 3, the increase in yield in August was confirmed by the correlation coefficient r=0.97, which was divided by a large amount of harvested fruits. The reason for the increase in yield during the late development phases was estimated by an increase in the mass of fruits. r = reduced to 0.82-0.92%.

So all the studied preparations have had an adequate effect on the yield of tomatoes. With a control of 22.1 kg/m^2, in experimental variants 28.6-30.1 kg/m^2 (Figure 1).

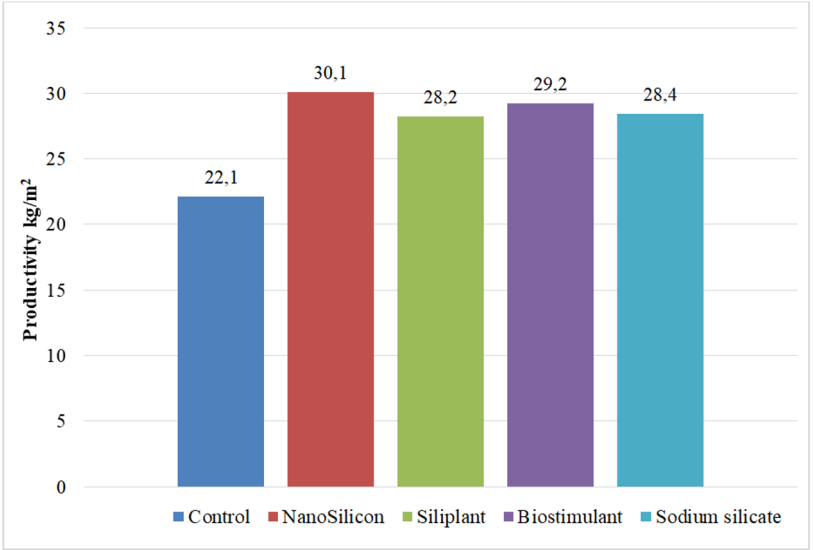

Fig. 1. Effects on tomato yield when using silicon-retaining preparations

The effect of all fertilizers is directly associated with sodium silicate. The reason for the addition to yield is due to the use of silicon, while the additional components in the drug do not play the main role.

When treated with silicon on plants, the number of picked tomato fruits was observed to increase the yield by 10-12%, regardless of the Shape of the preparations (Figure 2).

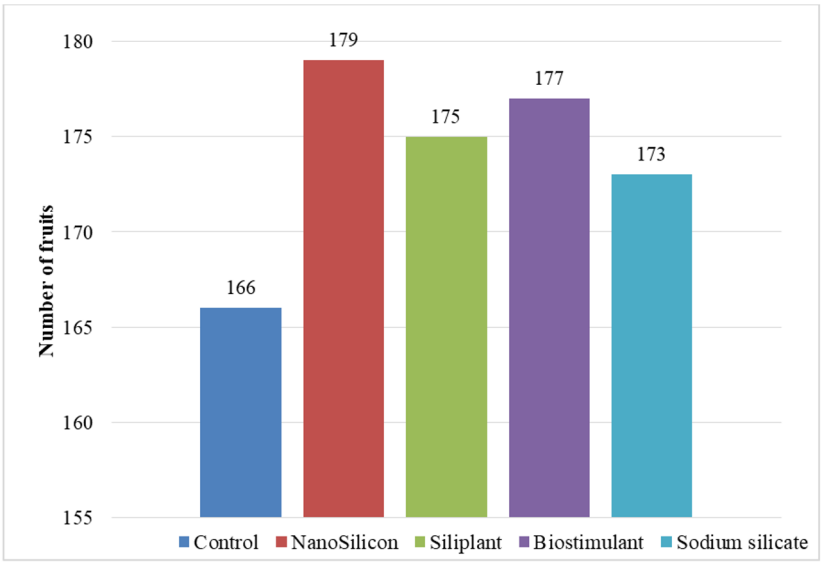

Fig. 2. The number of picked tomato fruits when using silicon-containing preparations.

A correlative bond was observed between the number of fruits and the total yield r=0.96. It was also observed that the total yield is related to the average mass of fruits (r=0.98), the yield increased by 18-23% due to the use of silicon. (Figure 3).

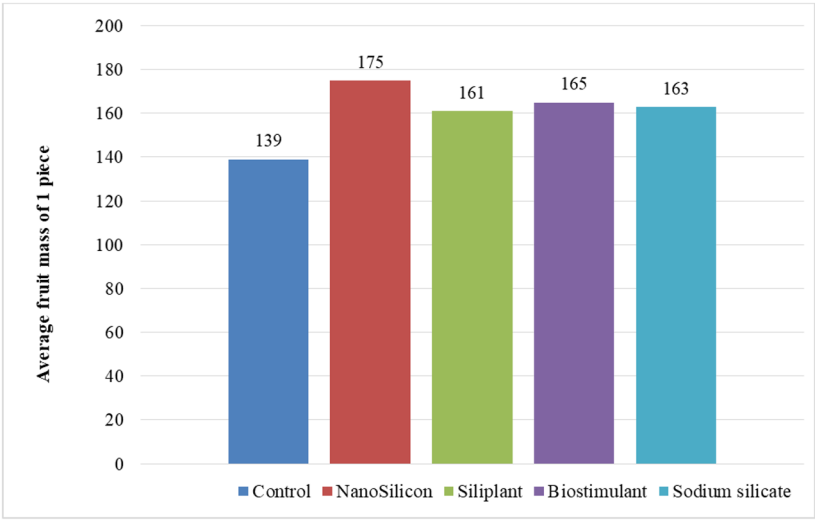

Fig. 3. An average of one tomato mass when using silicon-containing preparations.

The total amount of fertilizers spent during the experimental periods was N-80; P_2O_5-78; K_2-201 g/m_2. The effectiveness of fertilizers was further increased when applying the nutrients spent on the formation of a single unit of product (Table 4).

Table 4. The amount of exposure substances in fertilizers spent on the formation of 1kg tomatoes.

№	Option	Consumption of active ingredients in g/1kg of fruit		
		N	P_2O5	K_2O
1	Control	3,6	3,5	9,2
2	Nano silicon	2,7	2,6	6,8
3	Siliplant	2,8	2,7	7,1
4	Biostimulant	2,7	2,6	6,8
5	Sodium silicate	2,7	2,7	6,9

During the experiment, the consumption of moderate nitrogen, phosphor and potassium fertilizers decreased by 25% depending on the type of drug being used by spraying on crops in the place of the root.

Effect of silicon-containing preparations on cucumber yield. When calculating morpho biometric indicators, the use of silicon-containing fertilizers has had a positive effect on the growth and development of cucumbers (Table 5).

When compared to the control option, the number of intermediate joints in the plant increased by 32-40%. In this, the maximum number of intermediate joints was observed when the drug siliplant was used (79 Pcs.), in nanocremnium (76 Pcs.), in the biostimulator (75 Pcs.). Under the influence of all studied preparations, the foliariness of plants increased by 20-25% compared to control. This indicator has also been observed in other authors (9).

Silicon plays an important role in the metabolism of plants. The element silicon enhances the formation of 2-layer cuticular leaf plates and the mechanical properties of plant tissues, and reduces water asphyxiation, increasing plant resistance to diseases (3,6,15).

The chemical composition of cucumber leaf showed that under the influence of silicon-containing preparations, the amount of dry substance increased from 8.2% to 9.5% (Table 5).

During the experiment, there was an average lack of nitrogen. But its amount in the leaf increased by 3.1% to 3.2-4.6% when using silicon-containing preparations in control option. When sprayed with a bio stimulant, the nitrogen supply was at an optimal level. The phosphorus content in the leaf has gained an average indicator in all variants (2.7-2.2%). But the potassium content was higher than the optimal level (4.2-4.7%). The phosphorus and potassium indicator were observed to increase when used nanocremnium, siliplant and bio stimulant.

Table 5. Effect of silicon-containing preparations on the amount of dry substance contained in cucumber leaf.

Option	Month	Dry matter	N	P_2O_5	K_2O
Control	December	8,2	2,28	2,40	5,74
	January	8,3	3,86	2,01	5,42
	February	8,1	3,16	2,14	4,43
	χ	8,2	3,11	2,18	5,19
Nano silicon	December	8,9	2,14	2,59	5,96
	January	9,2	5,42	2,08	5,23
	February	8,5	4,45	2,47	5,13
	χ	8,9	4,00	2,38	5,44
Siliplanite	December	8,7	2,51	2,18	7,00
	January	8,8	2,79	1,79	5,42
	February	8,5	4,25	2,79	5,03

	χ	8,7	3,18	2,25	5,82
Biostimulant	December	9,5	4,77	2,13	5,54
	January	10,3	4,32	1,99	5,06
	February	8,6	4,60	2,38	5,16
	χ	9,5	4,56	2,17	5,25
Sodium silicate	Декабрь	9,0	3,67	2,15	5,70
	Январь	9,4	4,05	1,81	4,95
	Февраль	8,6	3,56	2,12	4,80
	χ	9,0	3,76	2,02	5,15

The resulting yield showed that all the fertilizers under study have a positive effect on the yield of cucumbers, and especially under the influence of siliplant and bio stimulant Bona Forte, this indicator will be at the maximum level (Table 6).

The yield of cucumbers for three months was able to obtain an additional yield from silicon-containing preparations when a siliplant and a bio stimulant were applied. When nanocremnium and sodium silicate were applied, however, little difference was observed using mathematical variational statistics.

Table 6. Yield of cucumbers in the application of silicon containing preparations

Option	**Productivity kg/m²**				**Number of fruits/m²**				**Average fruit mass (g)**			
	1*	**2**	**3**	**Σ**	**1**	**2**	**3**	**Σ**	**1**	**2**	**3**	**Σ**
Control	5,4	5,0	5,6	15,9	55	43	46	144	98	117	120	112
Nano silicon	6,4	5,4	5,7	17,4	61	45	47	154	104	118	120	114
Siliplanite	7,2	7,3	7,8	22,4	62	59	60	181	116	124	129	123
Biostimulant	7,0	7,0	7,2	21,2	64	58	59	181	110	121	122	118
Sodium silicate	6,2	5,0	5,9	17,2	59	42	48	149	106	119	124	116
r	-	-	-	-	0,90	1,00	0,99	0,99	0,87	0,84	0,77	0,89

*-December 1; January 2; February 3.

**- The coefficient of correlation between the yield indicator and the average fruit mass of the number of fruits.

Under the influence of preparations on the increase in yield, 2 main components of yield were formed: the number of fruits and their average mass. The main relationship in this was observed between the number of fruits and the yield (r=0.90-1.00).

During the three-month experiment, the yield was reliably increased compared to the control when using the drug silicon containing preparations. When using the drug Nano silicon and sodium silicate, an additional 1.3-1.5 kg/m^2 product was grown to yield. We can assure that siliplant and bio stimulant preparations have significantly affected the formation of an additional 5.3-6.5 kg/m^2 product, which is due to the fact that under the influence of microelements and biologically active substances that they contain.

The yield of fruits increased by 3-6% when sodium silicate and nano silica were used when the cucumber plant was treated with silicon. When exposed to bio stimulant and siliplant drugs, the yield increased by 25-26%. Between the number of fruits and the total yield there is a correlation bond: r=0.99. To a small extent, it depends on the average mass of the fruit, which increased by 2-11% when silicon was applied. It became as noted in the literature that all silicon-containing preparations affect the formation of the chemical composition of cucumber fruits. (9). When fed outside the root, the amount of dry substance in the fruits increased from 3.3 to 3.7% (Table 7).

Table 7. Dry matter content of fruits when fed foliarly

Option	Month	Dry matter %	Sugar	Wet crop	N	P_2O_5	K_2O	N-NO_3 мг/кг
Control	December	2,78	1,89	0,84	0,13	0,04	0,12	340
	January	3,52	2,53	0,89	0,14	0,06	0,21	408
	February	3,57	2,14	0,85	0,14	0,05	0,22	397
	χ	3,29	2,19	0,86	0,14	0,05	0,18	382
Nano silicon	December	3,67	2,50	0,51	0,08	0,04	0,16	282
	January	3,91	2,82	0,81	0,13	0,05	0,19	234
	February	3,47	2,43	0,79	0,13	0,05	0,18	174
	χ	3,68	2,58	0,70	0,11	0,05	0,18	230
Siliplanite	December	3,23	2,26	0,60	0,10	0,06	0,13	255
	January	3,78	2,72	0,82	0,13	0,05	0,19	275
	February	3,57	2,43	0,68	0,11	0,05	0,18	187
	X	3,53	2,47	0,70	0,11	0,05	0,17	222
Biostimulant	December	2,78	1,78	0,67	0,11	0,05	0,17	199
	January	3,63	2,54	0,91	0,15	0,06	0,17	204
	February	3,62	2,75	0,71	0,11	0,05	0,20	139
	X	3,64	2,34	0,76	0,12	0,05	0,18	181

When using silicon-containing preparations, the content of sugars in the fruits of cucumbers has a positive effect. In the control variant, the sugar content was 2.2% while in the experimental variants, when sprayed on crops with preparations, the sugar content was observed to increase to 2.3-2.6%.

During the experimental period, the consumption of feed elements amounted to N-103; P_2O_5-44; K_2O-160g/m2, the yield formation of 1 kg their consumption of fertilizers was in the range of N=4.6 -6.5; P_2O_5-2.0-2.8; K_2O-7.2-10.1 ha/kg.

Studies have shown that as a result of the use of drugs, the coefficient of assimilation of nutrient elements increased, and the cost of crop consumption decreased. The most efficiency in this was observed in variants where a siliplant and a biostimulator were used (Table 8)

Table 8. The norm of spent fertilizers is for the formation of 1 kg of cucumber fruit when using silicon-preserving preparations

Option	Intake of nutrients with fruits g/m Intake of nutrients with fruits g/m^2			Absorption of nutrients in g/kg fruit			The cost of additional fertilizers is g/kg		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Control	21,9	7,8	29,1	1,38	0,49	1,83	6,5	2,8	10,0
Nano silicon	19,6	8,3	30,8	1,13	0,48	1,77	5,9	2,5	9,2
Siliplanite	25,0	11,5	37,1	1,12	0,52	1,66	4,6	2,0	7,2
Biostimulant	25,9	10,9	39,0	1,22	0,51	1,84	4,9	2,1	7,6
Sodium silicate	19,0	8,4	32,5	1,11	0,49	1,89	6,0	2,6	9,3

4 Conclusion

For the norm of spent fertilizers is for the formation of 1 kg of cucumber fruit when applying silicon-containing preparations

The use of silicon-containing preparations when growing tomatoes and cucumbers in greenhouses has had a positive effect on the growth, development, yield of crops. Feeding

(spraying) with non-root preparations increased yield by 6.5-8.0 kg/m2, the reason is an increase in the number of fruits (10-12%), and their mass increased by 18-23%, as well as accelerating the ripening of fruits. The cost of crop formation decreased by 25%.

When processing cucumbers with the preparation of silicon, the absorption of nutrients increased and had a positive effect on the formation of the assimilation apparatus in plants. The number of leaves (20-25%) and the number of intermediate joints (32-49%) increased. Of the most affected preparation, the siliplant and bio stimulant are Bona Forte, which cause an additional yield (5.3-6.5 kg/m2), which, in our opinion, are biologically active substances and microelements that are part of them.

All studied preparations have shown a high-quality yield formation, as well as an increase in the amount of dry matter and sugars and a positive effect. Expenses on the formation of nutrient elements per unit of yield decreased by 8-10% in nano silicon, and by 25-29% when the preparation Bona Forte and siliplant was used.

Reference

1. Durnikova S.A. et al. Ways to improve cucumber protection when growing with low-volume technology. *Agrochemical Bulletin,* No. 6, 74-77 (2022).
2. Sagdiev M. T., Omonlikov A. U. Increasing the yield of cucumber and tomato in film greenhouses of the Tashkent region. European Journal of Interdisciplinary Research and Development. Vol. **4.** 113-121 (2022).
3. Sagdiev M. T., Amanova M., Omonlikov A. U. The influence of a growth regulator on the yield of sweet pepper. *Eurasian Union of Scientists*.. – No. **4-7 (61).** 50-52 (2019).
4. Sagdiev M., Omonlikov A. Increasing the quality and productivity of tomato fruits under the impact of a growth regulator. *International scientific and practical conference*. 22 (2023).
5. Sagdiev M. T., Amanova M., Omonlikov A. U. Annotation effect of growth regulator on the yield of sweet pepper . *Eurasian Unio n of Scientists*. **61.** 50-52 (2019).
6. Sagdiev M.T., Omonlikov A., Amanova M. Effect of stimulators on yield and quality of white cabbage. *Bulletin of Agrarian Science of Uzbekistan*. **№. 83.** 218-219 (2020).
7. Sagdiev M., Omonlikov A. Influence of plant growth stimulants on tomato productivity in the conditions of the tashkent oasis. *Journal of Agriculture & Horticulture*. **№. 4.** 58-63 (2023).
8. 8. Malyavin A.S. et al. Production of mineral fertilizers. *Encyclopedia of technologies 2.0: Chemical Corps Moscow*. 11-88 (2022).
9. Alimova, R., Sagdiev, M., Omonlikov, A. Increasing the quality and productivity of tomato fruits under the impact of a growth regulators. *E3S Web of Conferences*, **421,** 02008 (2023).
10. Nabiev, S., Sagdiev, M., Alimova, R. Physiological indicators of water metabolism in plants of parental forms and F_1 hybrids of G. Barbadense L. cotton type under different water supply conditions. *E3S Web of Conferences*, **421,** 05003 (2023).
11. Usmanov, R., Madaminov, R., Jumaniyazov, F., Sobirov, E., Sagdiev, M.T. Assessment of drought stress impact on winter wheat using landsat 8 images: Comparison of field data and vegetation indices. *IOP Conference Series: Earth and Environmental Science*, **1142(1),** 012082. (2023).
12. Usmanov, R.M., Nabiev, S.M., Lukyanova, S.V., Sagdiev, M.T., Hamdullaev, S.A. Influence of physicochemical factors on water exchange in cotton leaves under the

moisture deficit conditions. *IOP Conference Series: Earth and Environmental Science*, **939(1),** 012051 (2021).

13. Matychenkov I.I., Bocharnikova E.A. et al. Prospects for the use of silicon preparations in agriculture. *Soil Science and Agrochemistry*. **№1(68),** 219-234 (2022).
14. 14. Polyakova E.V. et al. Growing seedless tomato using biostimulants. *Bulletin of Kras.* **№6,** 3-10 (2021).
15. 15. Selivanova M.V. Efficiency of using silicon-containing fertilizers in low-volume cucumber growing technology. *Vegetables of Russia*. **№6.** 25-30 (2020).
16. Agriculture in Russia 2021. Statistical digest of Rosstat. *Moscow*. 100. (2021).
17. Khoroshilov A.A., Frolova S.A. Use of mineral fertilizers with Nano-Silicon microelements in the technology of cucumber cultivation in closed ground. *Scientific journal of young scientists.* No. **2 (9).** 10-13 (2017).
18. Effect of seed treatment by selenium and silicon on the absorption of heavy metals by barley plants under soil drought. *Bulgarian Journal of Agricultural Science*. **№2.** 328-332 (2021).
19. Epstein E. Silicon // Annu. Rev.Plant Physiol. *Plant Mol Biol*. **№50.** 641-664 (1999).
20. Khojanazarova M., Artikova R., Khalmuminova G., Omonlikov A. Spectrophotometric indicators of "Zamin-M" biopreparation immobilized with gypan flocculinate. *E3S Web of Conferences* **389,** 03076 (2023). https://doi.org/10.1051/e3sconf/202338903076
21. Jumanazarov G., Rakhmanov U., Omonlikov A., Businov M. Determination of the pathogenicity of the fungi Leveillula Saxifragacearum and Sphaerotheca Mors Uvae causing mildew disease // *E3S Web of Conferences* **421,** 02007 (2023). https://doi.org/10.1051/e3sconf/202342102007
22. Abdiev, Z., Khurramov, U., Karimov, J., Zokirov, K., Omonov, M., Jumanov, L., & Ruzmetov, G. The influence of nutrition and various materials on tomato cultivation in hydroponics. *E3S Web of Conferences*, Vol. **452**, 01012 (2023). https://doi.org/10.1051/e3sconf/202345201012
23. Buriev, K., & Zokirov, K. Seasonal and daily blooming rhythm of cucumber (Cucumis sativus) belonging to Cucurbitaceae family. *E3S Web of Conferences,* Vol. **452**, 01015 (2023). https://doi.org/10.1051/e3sconf/202345201015
24. Buriev, K., & Zokirov, K. Seasonal and daily blooming rhythm of watermelon (Citrullus lanatus) belonging to Cucurbitaceae family. *E3S Web of Conferences,* Vol. **452**, 01014 (2023). https://doi.org/10.1051/e3sconf/202345201014
25. Khalikov, B., Mukhamatzanova, R., Sullieva, S., Zokirov, K., & Nishonova, A. Effect of planting time and seedling feeding area on leek (Allium porrum) plant biometric parameters. *BIO Web of Conferences*, **93,** 02020 (2024). https://doi.org/10.1051/bioconf/20249302020
26. Khalikov, B., Zokirov, K., Sullieva, S., & Nishonova, A. Effect of planting time and seedling feeding area on changes in the number and area of leek leaves. *BIO Web of Conferences*, **93,** 02021 (2024). https://doi.org/10.1051/bioconf/20249302021
27. Khurramov, U., Abdiev, Z., Karimov, J., Zokirov, K., Omonov, M., Jumanov, L., & Ruzmetov, G. The influence of the norm of feeding on the growth and yield of early-ripening potatoes. *E3S Web of Conferences,* Vol. **452**, 01013 (2023). https://doi.org/10.1051/e3sconf/202345201013
28. Rifky, M., Abdusalomova, D., Dissanayake, K., Zokirov, K., Harris, J. M., Jesfar, M., Esonboyev, F., & Samadiy, M. Seaweed as a functional ingredient and emulsifier in

dairy processing. *BIO Web of Conferences*, **108,** 18001 (2024). https://doi.org/10.1051/bioconf/202410818001

29. Sullieva, S., Zokirov, K., Khalikov, B., Nishonova, A., & Negmatova, S. Varieties and hybrids of leek (Allium porrum) in the conditions of Uzbekistan. *BIO Web of Conferences*, **93,** 02019 (2024). https://doi.org/10.1051/bioconf/20249302019
30. Sullieva, S., Zokirov, K., Nishonov, N., Atamuratova, N., & Abdullayev, B. Effect of planting time and seedling feeding area on the yield and biochemical composition of leek (Allium porrum L.). *BIO Web of Conferences*, Vol. **93**, 02006 (2024). https://doi.org/10.1051/bioconf/20249302006
31. Zokirov, K. Effect of drip irrigation regimes and mineral fertilizer rates on watermelon yield in mulched fields. *E3S Web of Conferences*, Vol. **389**, 03067 (2023). https://doi.org/10.1051/e3sconf/202338903067
32. Zokirov, K. Irrigation regimes for drip irrigation of watermelon in mulched and non-mulched fields. *E3S Web of Conferences*, Vol. **389**, 03068 (2023). https://doi.org/10.1051/e3sconf/202338903068
33. Zokirov, K., & Sullieva, S. Effect of storage conditions and periods on the quality of watermelon (Citrullus lanatus). *E3S Web of Conferences*, **452,** 01016 (2023). https://doi.org/10.1051/e3sconf/202345201016
34. Zokirov, K., Sullieva, S., Abdullayev, D., Abdinazarova, X., Tojiyeva, F., Naurizbaev, A., & Qodirov, F. Watermelon yield in both mulched and unmulched fields: The impact of drip irrigation on watermelon production. *BIO Web of Conferences*, **130,** 01030 (2024). https://doi.org/10.1051/bioconf/202413001030