Effect of Nano- And Microparticles on Germination and Development of Tomato Plants

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ABSTRACT

The article contains information on the application of generite (Co, Cu, Zn, Mn), silicon dioxide (SiO_2), manganese dioxide (MnO_2) and iron oxide (Fe_2O_3) nano and microparticles to tomato crops, as well as the effects of these particles and their compositions on the germination of tomato seeds the results of the experiment conducted in order to study the effect on the yield and the development of its seedlings are presented. Before planting tomato seeds, silicon dioxide (SiO_2), manganese dioxide (MnO_2) and iron oxide (Fe_2O_3) 1 g each and silicon dioxide (SiO_2)+manganese dioxide (MnO_2)+iron oxide (Fe_2O_3)-1,5 g An effective effect on fertility was observed. If manganese dioxide (MnO_2) and iron oxide (Fe_2O_3) are added to tomato seedlings grown from tomato seeds at the rate of 1 gram per 10 liters of water, a positive effect on the development of the plant was found. It was observed that 10% and 75% flowering was 6-7 days earlier in the variants using silicon (SiO_2), manganese (MnO_2) and iron (Fe_2O_3) oxides. In turn, it was found that fruiting in these variants was 9-10 days earlier (10%) compared to the control, and at the same time, it was observed that the obtained yield was significantly higher.

Keywords: Nanoparticle, plant, tomato, seeds, seedling, potassium, magnesium, molybdenum, nano silicon, silicon dioxide, manganese dioxide, iron oxide

Introduction

Vegetable crops have the property of accumulating water in their cells. The saturation of cells and tissues with water allows to accelerate the metabolism and enzyme formation reactions in the plant. This feature of vegetable crops allows to collect abundant harvest. It also causes plant resistance to mechanical damage and diseases, increased consumption of plastic substances during respiration, and increased water evaporation during product storage. In the scientific researches of foreign scientists, cucumber fruits, lettuce and spinach leaves retain water in the largest amount (94-96%), and the minimum level (73-80%) in root vegetables and bulbs. Carbohydrates make up 45% of the dry matter in the plant, oxygen makes up 42% and nitrogen makes up 1,5%. Residual (ash) elements formed from the combustion of organic matter will be 5%. Ash also contains many elements: potassium, phosphorus, sulfur, calcium, magnesium, iron, silicon, sodium chloride, etc. It is noted that the residual elements, which make up a very small amount (1% of the ash content or 0.05% of the dry matter of the plant) consist of trace elements[1].

The initial change in the color of young plant leaves is caused by the lack of manganese, iron, and zinc elements. The change in the color of the old leaves of plants is a sign of a lack of elements potassium, magnesium, molybdenum. Boron deficiency primarily affects the growth of root and stem tissues. When there is a lack of phosphorus element (without symptoms of chlorosis), the growth slows down. When there is a lack of nitrogen, sulfur, and copper elements, the plant's growth slows down, and symptoms of chlorosis appear [2].

The symptoms that occur due to the lack of mineral nutrients in the plant can be drought, excessive moisture, frost, damage to the root neck of plants or damage caused by diseases and pests, and the type of soil can affect it. Correct determination of the lack of mineral elements and timely feeding of plants with the appropriate mineral elements allows to prevent the lack of elements in young leaves, partly in old leaves [3].

Today, in organic farming, macro-, micro-, and meso-elements for plants are widely used in agricultural crops of foreign countries.

In the experimental studies of Zelenkov, Potapov, Petrichenko in Russia in 2016-2019, the possibility of increasing the photosynthesis rate and plant productivity using new biotechnological approaches for the first time when treated in plant seeds and leaves using sol concentrates of hydrothermally generated SiO_2 nanoparticles from 9 to 60% observed to occur [3; 4].

The elements included in nanotechnology are divided into 3:

1-macro elements (nitrogen, phosphorus, potassium)

2- trace elements (iron, boron, copper, zinc, manganese, silicon, etc.)

3 - mesoelements (calcium, magnesium, sulfur)

At the Institute of Ion-Plasma and Laser Technologies of the Academy of Sciences of the Republic of Uzbekistan, an experimental device was created to obtain nano and microparticle powders of amorphous silicon dioxide (SiO_2), iron, manganese and other elements. is being implemented. In this, man-made wastes of a number of metallurgical enterprises of the Republic of Uzbekistan are widely used as raw materials.

Materials And Methods

In cooperation with the Institute of Ion-Plasma and Laser Technologies, Research Instirute of Vegetable, melon crops and potato used nano and microparticles in various variants to study the effect on the development of seeds and seedlings of tomato plants. For this, 50 seeds of tomato plants were counted in a petri dish. Experiments were carried out in 3 repetitions and collected in a thermostat at a temperature of 25°C.

Experience -1:

1. Control (unprocessed)
2. Generite (Co, Cu, Zn, Mn)
3. Silicon dioxide (SiO_2), Russia
4. Silicon dioxide (SiO_2), local
5. Manganese dioxide (MnO_2)
6. Iron oxide (Fe_2O_3)
7. SiO_2+ MnO_2+Fe_2O_3 –(0,5+0,5+0,5) =1,5gr
8. SiO_2+ MnO_2+Fe_2O_3 –(1,0+1,0+1,0) = 3,0g
9. SiO_2+ MnO_2+Fe_2O_3 –(1,5+1,5+1,5) = 4,5g

Experiment -2:

Mineral fertilizers were given to each of the variants in the observations during the growth period of the planted tomato as follows: $N_{200}P_{150}K_{100}$ in the recommended rates for vegetable crops and the amounts are given in the tables for the variants.

Results

The effect of nanoparticles and microparticles on the germination of tomato seeds is presented in Table 1. As can be seen from this table, 94,6-95,4% germination of seeds was observed on the 6th day in the variants using 1 g of silicon dioxide (SiO_2), manganese dioxide (MnO_2) and iron oxide (Fe_2O_3). When local silicon dioxide (SiO_2)+manganese dioxide (MnO_2)+iron oxide (Fe2O3) - 1g and local silicon dioxide (SiO_2)+manganese dioxide (MnO_2)+iron oxide (Fe_2O_3) - 1,5g are applied to tomato seeds, 6 chi 96,0-97,4% germination was found by day (Fig. 1), this indicator was 82% in our control option.

Table 1
Effects of nano and microparticles on the germination of tomato seeds
(laboratory experience "Barlos" 14.02.2021-2022)

№	Variant	Number of seeds, pcs	*Number of germinated seeds, by days*						%
			1	*2*	*3*	*4*	*5*	*6*	
1	Control	50	-	-	17.7	30.3	36.7	41,0	82,0
2	Genereit (Co,Cu, Zn, Mn)	50	-	-	28,0	35,0	40.3	45,0	90,0
3	SiO_2 - Russia	50	-	-	24.7	37.3	42,0	45,0	90,0
4	SiO_2 - Local	50	-	-	29.7	35,0	40.7	47.3	94.6
5	MnO_2	50	-	-	27.7	40,0	44.7	47,0	94,0
6	Fe_2O_3	50	-	-	28.7	40.3	44.7	48.7	95.4
7	SiO_2+ MnO_2+ Fe_2O_3	50	-	-	30.0	38,0	42,0	46.3	92.6
8	SiO_2+ MnO_2+ Fe_2O_3	50	-	-	31.3	39.7	44,0	48.7	97.4
9	SiO_2+ MnO_2+ Fe_2O_3	50	-	-	27.7	38,0	39.7	48,0	96,0

In order to study the effect of nanomicroparticles on the development of tomato seedlings planted in the nursery, experiments were carried out in different (mentioned above) options. In this case, among the options that achieved the best results, iron oxide - Fe_2O_3 and manganese dioxide - MnO_2 (options 5-6, 1 gram per 10 liters of water) were used, on the 45th day after planting, the number of side branches on the plant was on average 3,6-3,7, and the number of leaves It was determined that there will be more than 16. In these variants, the length of the plant root is 16,8-17,2 cm, and (Fig. 2) the thickness of the rhizome is 0,4-0,46 mm was observed to be equal to Table 2.

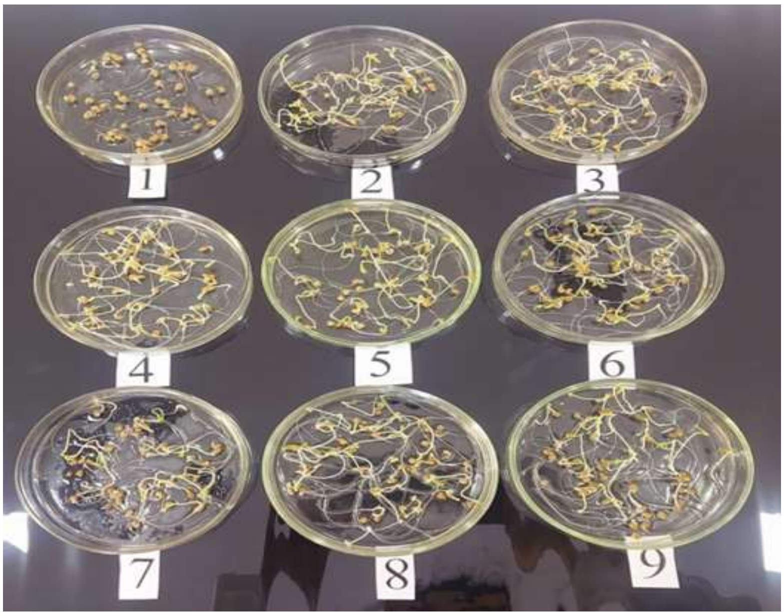

Fig. 1. Germination of tomato seeds under laboratory conditions

In addition, the height of the plants after 45 days is 29 cm in the variant with the addition of nanomicroparticles silicon dioxide (SiO_2) + Manganese dioxide (MnO_2) + Iron oxide (Fe_2O_3) was 0,46 mm. It was observed that the effect of these indicators was high compared to the control.

Table 2
Effects of nano and microparticles on the development of tomato seedlings
(laboratory experience "Barlos" 2021-2022)

№	Variant	*Biometric indicators of seedlings*				
		height, cm	*side branches number, piece*	*number of leaves, piece*	*root length, cm*	*root throat thickness, mm*
1	Control	17.3	2.6	13.0	7,0	0.1
2	Genereit (Co,Cu, Zn, Mn)	20,0	3,0	14	10.1	0.27
3	Nano Silicon (SiO_2)	21,0	3.3	16	11.2	0.3
4	SiO_2	22	3.6	16.7	11.7	0.3
5	MnO_2	21.6	3.7	16.3	16.8	0.5
6	Fe_2O_3	26,0	3.6	18.1	17.2	0.4
7	SiO_2+ MnO_2+ Fe_2O_3	27.7	3.6	17.3	8.2	0.43
8	SiO_2+ MnO_2+ Fe_2O_3	29	4,0	21,0	15,0	0.46

The results of experiments on the effect of nanoparticles and microparticles on the phenological indicators of tomatoes are presented in Table 3. As can be seen from this table, it was observed that 10% and 75% flowering was 6-7 earlier compared to the control in the options where silicon (SiO_2), manganese (MnO_2) and iron (Fe_2O_3) oxides were used. In turn, fruiting in these variants was also found to be 9-10 days (10%) earlier than in the control.

Fig. 2. Effects of nano and microparticles on tomato root development

Table 3
Effects of nanoparticles and microparticles on tomato phenological parameters
(lysimeter experiments 2021-2022)

№		Vegetation period, days

	Variant	Flowering		Fruit bearing	
		10 %	75 %	10 %	75 %
1	No fertilizer - control	21	25	31	35
2	$N_{200}P_{150}K_{100}$ (benchmark)	18	21	27	33
3	Genereit	16	18	25	28
4	SiO_2 Russia	15	19	25	27
5	SiO_2 local	15	19	22	26
6	MnO_2	16	18	23	27
7	Fe_2O_3	14	18	21	27

The effect of nanoparticles and microparticles on the biometric indicators of tomatoes (lysimeter) is presented in Table 4. At the end of the vegetation period, the height of the plant was 47 cm in the control variant when nanoparticles and microparticles were used in tomatoes. In the version of the recommended norm (benchmark) for tomato crops, $N_{200}P_{150}K_{100}$ was used, this indicator was 64,8 cm, and in the 3rd variant where Genereit was used, it was 68.8 cm, SiO_2 (Russia) 69,2 cm in the 4th variant used, and 70.6 cm in the 5th variant of SiO_2 (local), 68,5 cm in the 6th MnO_2 variant, and 70,1 cm in the variants using Fe_2O_3.

At the end of the tomato growing period, the number of lateral branches was 1.8 in the control variant, and the thickness of the stem was 0.9 mm. 2nd $N_{200}P_{150}K_{100}$, in the standard (standard) version, the number of side branches was 2.8 units, and the thickness of the stem was 1,25 mm. In the 3rd generation, the number of side branches was 3,5, and the thickness of the stem was determined to be 1,5 mm. In the 4th option, where SiO_2 (Russia) was used, the number of side branches was 3,6, and the thickness of the stem was determined to be 1,6 mm. It was observed that the number of lateral branches was 3,9 units, and the thickness of the stem was equal to 1,65 mm in the 5th variant where SiO_2 (local) was used in tomato. In the 6th and 7th variants where MnO_2 and Fe_2O_3 were used, the number of side branches was 4,0-4,2, and the thickness of the tomato stem was 1,75-1,80 mm. So, it was found out from these experiments that the effect of nano and microparticles on the biometric parameters of tomato was observed to be higher than the control.

Table 4
Effects of applied nanoparticles and microparticles on tomato biometric indicators (lysimeter experiments 2021)

№	Variant	Flowering period			Fruiting period			The end of the growing season		
		height, cm	number of lateral branches,	stem thickness	height, cm	number of lateral branches, pcs	stem thickness	height, cm	number of lateral branches, pcs	stem thickness
1	No fertilizer - control	36,3	1,6	0,7	43,2	1,8	0,9	47	1,8	0,9
2	$N_{200}P_{150}K_{100}$ (benchmark)	47,5	2,3	0,92	59,2	2,7	1,1	64,8	2,8	1,25
3	Genereit	55,4	3,3	1,11	62,9	3,15	1,3	68,8	3,5	1,5
4	SiO_2 Russia	55,0	3,2	1,05	63,1	3,5	1,4	69,2	3,6	1,6
5	SiO_2 local	54,7	3,0	1,0	65,9	3,8	1,45	70,6	3,9	1,65
6	MnO_2	55,4	2,9	1,1	61,7	3,7	1,5	68,5	4,0	1,75
7	Fe_2O_3	55,0	3,3	1,15	64,0	3,9	1,55	70,1	4,2	1,8

The effect of applied nanoparticles and microparticles on tomato yield is presented in table 5, in the variant used without fertilizer (control), a total of 116,5 g per bush, in the 2 variants of the standard (standard) recommended for $N_{200}P_{150}K_{100}$ tomato crops, the weight of the crop is 346,1 g, a 255,4% higher yield was obtained compared to the control variant. The 3rd variant Genereit yielded 346,1 g, which was 297,1% higher than the control variant.

In 4 variants using SiO_2 (Russia), the yield from one bush was 355,8 g, and in this variant, the yield was 205,4% higher than the control variant. When local SiO_2 of the 5th option was used, the weight of the fruits was 381,7 grams, and the yield was 227,6% higher than the control. 6 variants In the variant using MnO_2, a total of 368,8 g was obtained from one bush, and the yield compared to the control variant was 216,5% higher.

The weight of the harvested crop from variant 7, where Fe_2O_3 was used, was 397,9 g. When Fe_2O_3 is used, 241,5% higher yield compared to the control variant has been proven in our lysimeter experiments.

Table 5
Effects of applied nanoparticles and microparticles on tomato yield
(lysimeter experiments 2021)

№	Variant	Average yield per bush, grams	Relative to control, %	Relative to the standard, %
1	No fertilizer - control	116,5	100	-
2	$N_{200}P_{150}K_{100}$ (benchmark)	297,6	255,4	100
3	Genereit	346,1	297,1	116,4
4	SiO_2 Russia	355,8	205,4	119,5
5	SiO_2 local	381,7	227,6	128,2
6	MnO_2	368,8	216,5	123,9
7	Fe_2O_3	397,9	241,5	133,7

Conclusions

So, before planting tomato seeds, silicon dioxide (SiO_2), manganese dioxide (MnO_2) and iron oxide (Fe_2O_3) 1 g each, and silicon dioxide (SiO_2) + manganese dioxide (MnO_2) + iron oxide (Fe_2O_3) – 1,5 g. It has been proven in the conducted experiments that it has an effective effect on fertility when processed.

If manganese dioxide (MnO_2) and iron oxide (Fe_2O_3) are added to 10 liters of water and poured under the seedling, a positive effect on the development of the plant was found.

It was observed that 10% and 75% of the varieties with silicon (SiO_2), manganese (MnO_2) and iron (Fe_2O_3) oxides bloomed 6-7 earlier than the control. In turn, it was found that in these variants, the fruit set is 9-10 days (10%) earlier than in the control, and at the same time, the obtained yield is significantly higher.

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