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### IMPROVING CULTIVATION TECHNOLOGY FOR SWEET PEPPERS

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#### ABSTRACT

The objective of this research was to refine open-field cultivation technologies for sweet peppers by enhancing yield through the application of foliar-based growth regulators. The study was conducted between 2022 and 2024 under the agro-climatic conditions of the Tashkent region. Experiments utilized the following sweet pepper hybrids: Gemini F<sub>1</sub>, Abadiya F<sub>1</sub>, and Nargiza F<sub>1</sub>. The methodology integrated a drip irrigation system with the application of growth-stimulating preparations, specifically T-86 and Bist, at concentrations of 1.0 ml and 1.5 ml per liter of water. The treatment protocol involved three successive applications of the working solution, administered via foliar spraying at a rate of 1 L per 30 m<sup>2</sup>.

During the research period, the application of the growth regulator T-86 at a concentration of 1.5 ml per liter of water yielded the most significant results. Specifically, for the Nargiza hybrid, the biological yield reached 104.2 t/ha, with a marketable yield of 101.4 t/ha (representing a surplus of 44.0 t/ha over the control group). Under the same parameters, the Abadiya F<sub>1</sub> hybrid produced an additional yield of 40.4 t/ha, while the Gemini F<sub>1</sub> hybrid showed an increase of 32.5 t/ha. On average across all hybrids, the combined application of T-86 and Bist at the specified higher dosage resulted in a surplus of 38.3 t/ha compared to the control. When the concentration was reduced to 1.0 ml/l, the average surplus yield dropped to 30.1 t/ha, indicating a yield decrease of 8.2 t/ha relative to the

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higher concentration. The optimal economic outcome was observed with three successive applications of T-86 and Bist at the 1.5 ml/l concentration. This treatment regimen generated a profit of 361.2 million UZS/ha, reflecting a net gain of 37.9 million UZS/ha. For the Gemini F<sub>1</sub> hybrid, a profit of 43.8 million UZS/ha over the control was recorded at the 1.0 ml/l concentration.

**Keywords:** Sweet pepper, hybrid, drip irrigation, fertilizers, yield, marketability, mechanical strength, economic efficiency.

### Introduction

Sweet pepper cultivation is extensively established across the soil and climatic conditions of Uzbekistan. To ensure sustainable yields, it is essential to implement drip irrigation systems and utilize high-yielding varieties and hybrids adapted to local environments (1,2,3).

The increase in sweet pepper productivity under the influence of growth-regulating preparations has been well-substantiated (4,5,6). In modern technologies, the significance of growth stimulants is increasing, as they are applied in low concentrations and have demonstrated no adverse effects on the plants (7,8,9).

Scientific results conducted in the Tashkent region have demonstrated that sweet pepper crops treated with stimulants exhibit resistance to diseases, as well as high yields and superior fruit quality (10).

The natural climatic conditions of Uzbekistan for pepper cultivation require the consideration of certain challenges regarding the diversity of sweet pepper varieties and their agrotechnological support. Addressing these issues will lead to increased efficiency in sweet pepper production.

The research objective was to evaluate the agronomic efficiency of the preparations T-86 and Bist, and to study their effects at various concentrations on sweet pepper varieties and hybrids under the conditions of the Tashkent region.

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The studies were conducted from 2022 to 2024 in the Qibray district of the Tashkent region. The experimental methodology followed generally accepted standards (Dospekhov B.A.).

The soil of the experimental plot is classified as ordinary typical light-colored sierozem, with a humus content of 1.5% in the 0-20 cm layer. The soil pH is 7.2 units, and the average chlorine content is 0.01%. The forms of ammonium ( $\text{NH}_4^+$ ) and nitrate ( $\text{NO}_3^-$ ) nitrogen were distributed as follows: exchangeable ammonium accounted for 18.3% (of the total nitrogen content), while nitrates accounted for 81.7%.

It is well known that an ammonium nitrogen content of 5–25% is considered optimal for plants. The content of primary macronutrients consisted of phosphorus (available form) at 28 mg/kg and exchangeable potassium at 151 mg/kg.

The following varieties were selected as the objects of study: Gemini F<sub>1</sub>, Abadiya F<sub>1</sub>, and Nargiza F<sub>1</sub>.

Gemini F<sub>1</sub> is an early-maturing hybrid that ripens in 100–110 days. It is characterized by excellent fruit-setting properties and is considered a variety that provides stable yields. It is recommended for cultivation in both open fields and greenhouses. The plants are tall and semi-spreading, forming 10–12 fruits simultaneously. The yield capacity is 7–8 kg/m<sup>2</sup>. The fruits are cylindrical with a smooth surface, thick walls (8–9 mm), and an average mass of approximately 170–180 g.

Abadiya F<sub>1</sub> is an early-maturing variety that ripens in 95–100 days. The fruits are cylindrical in shape, with a length of 9–10 cm and a diameter of 6–7 cm, while the fruit mass ranges from 120–130 g. During the technical maturity stage, the fruits are green, turning deep orange upon reaching full biological maturity. The plants are medium-sized, reaching a height of 60–70 cm.

Nargiza F<sub>1</sub> is a variety recommended for planting in all regions and is included in the state register, distinguished by its early maturity. The plants are of medium

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height and have a spreading (branched) growth habit. The average weight of the fruit is 150–160 g with a light bluish-green color. It features 3–4 seed chambers, a wall thickness of 7–8 mm, and reaching a yield of 6.5–7 kg/m<sup>2</sup>. It is suitable for a wide range of uses and is distinguished by its sweet flavor.

The experiments were conducted in four replications, with the distribution of plots organized using a randomized method. Each calculation plot covered an area of 25 m<sup>2</sup>, with a total experimental area of 675 m<sup>2</sup>. The experimental design included the following variables: variety (Factor A) - Gemini F<sub>1</sub>, Abadiya F<sub>1</sub>, and Nargiza F<sub>1</sub>; and foliar treatment with growth regulators (Factor B) - including a control group without treatment. The Bist preparation was prepared at concentrations of 1.0 ml and 1.5 ml per 1 liter of water.

T-86 and Bist (600 g/l) are chlormequat chloride growth regulators, registered at the experimental farm of the Tashkent State Agrarian University (TSAU). The purpose of applying these preparations was to activate the root system, enhance growth and development processes, increase yield, and improve the quality of the seedlings.

These preparations facilitate the formation of robust root systems and thick, sturdy stems in plants. They stimulate early flowering and ensure the active progression and duration of these biological processes, ultimately exerting a positive influence on fruit setting and overall productivity.

Methods of application: The seedlings underwent a triple-cycle spraying process. the first treatment was administered at the 3–4 true leaf stage, followed by the second and third applications at 8-day intervals. The working solution was applied at a rate of 1 liter per 30 m<sup>2</sup> of area.

Spring field preparations included plowing to a depth of 22–24 cm and two cycles of cultivation using a KPS-5 cultivator. Prior to transplanting the seedlings, the soil was processed with a rotary tiller (Fraser), and drip irrigation tapes were installed.

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Based on sweet pepper cultivation technology, 30–35-day-old seedlings were manually transplanted into the fields of the Tashkent State Agrarian University experimental farm during the second decade of April. The planting density followed the recommended rate of 40.8 thousand plants per hectare. The seedlings were planted using a double-row ribbon method designed for drip irrigation. The distance between rows was 30 cm, with an intra-row plant spacing of 35 cm. The distance between irrigation tapes was 1.4 m, providing each plant with a nutrition area of 0.245 m<sup>2</sup>.

Fruit quality was assessed using a 5-point scale, where 1 point represents unsuitable for consumption and 5 points indicates high-quality produce. Fruit tasting and sensory evaluation were conducted at the peak of the fruiting period, involving the inspection of 5 sample fruits from each variety. The mechanical strength of the fruits was determined using a Fruit Hardness Tester GY-0.9 penetrometer, based on a sample size of 10 plants.

A drip irrigation system was employed to manage soil moisture within the root zone. Subsurface irrigation was initiated 10 days after transplanting the seedlings. The second irrigation cycle was conducted 14 days after the first.

Prior to sowing, the pepper seeds were treated with a warm solution of KMnO<sub>4</sub> (potassium permanganate). Before transplanting the seedlings, the soil was treated with the herbicide Gaitan (EC, 3.5 L/ha). During the vegetation period, Elil (EC, 2 L/ha) was administered through the drip irrigation system. Protective treatments during the growing season were applied using a sprayer according to manufacturer norms, including Aktara (WDG, 0.4 kg/ha), ME (0.1 L/ha), and Kurzat (WP, 2.5 kg/ha). Additionally, the area around the seedlings was loosened using a hand hoe, and the harvest was collected manually. Economic efficiency was determined by calculating total production costs based on the technological map.

Within the multi-year observation period, May 2022 was relatively warmer, with an average daily temperature of +23.8°C, which was 2.7°C above the norm. Air

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humidity was lower compared to the long-term average of +19.6°C. The sum of active temperatures above +10°C reached an annual total of 697.5°C. In June, average daily temperatures fluctuated between +19°C and +39.5°C. Temperatures also remained high during July and August. The hydrothermal coefficient was 0.25 in 2022, 0.32 in 2023, and 0.41 in 2024 (based on meteorological station data).

Statistical processing of the experimental results was performed using analysis of variance (ANOVA) according to the B.A. Dospekhov method, utilizing Microsoft Office software.

During the years of the experiment, no statistically significant variations were observed in the growth and development phases of the plants across the studied variants.

The application of T-86 and Bist preparations at the higher concentration (1.5 ml per 1 liter of water) positively influenced sweet pepper productivity, specifically increasing both the number of fruits and their total mass. The highest yield was recorded in the Gemini F<sub>1</sub> variety at 88.4 t/ha, while the Abadiya F<sub>1</sub> hybrid showed a yield increase of 5.1 t/ha compared to Nargiza F<sub>1</sub> (Table 1).

**Table-1 Yield Structure Elements of Sweet Pepper (Average for 2022–2024)**

| Variety               | Treated variant (Factor A)       | Total number of fruits (piece) | Number of marketable fruit (piece) | Average mass of fruit (g) | Average number of fruits per plant (piece) | Total yield (t/ha) | Marketability % |
|-----------------------|----------------------------------|--------------------------------|------------------------------------|---------------------------|--|--------------------|-----------------|
| Gemini F <sub>1</sub> | 1) Untreated (control)           | 196                            | 190                                | 97,0                      | 20   | 67,6               | 95,4            |
|                       | 2). T-86, Bist at 1,0 ml/l water | 224                            | 215                                | 122,9                     | 22   | 98,0               | 96,0            |
|                       | 3) T-86, Bist at 1,5ml/l water   | 240                            | 234                                | 117,0                     | 24   | 99,5               | 97,5            |
|                       | Average by Factor A              | 220                            | 213                                | 112,3                     | 22   | 88,4               | 96,5            |

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|                        |                                  |     |     |       |    |       |      |
|------------------------|----------------------------------|-----|-----|-------|----|-------|------|
| Abadiya F <sub>1</sub> | 1) Untreated (control)           | 185 | 176 | 93,7  | 19 | 62,0  | 95,3 |
|                        | 2). T-86, Bist at 1,0 ml/l water | 220 | 213 | 124,4 | 22 | 96,8  | 96,8 |
|                        | 3) T-86, Bist at 1,5ml/l water   | 242 | 236 | 119,7 | 24 | 102,7 | 97,5 |
|                        | Average by Factor A              | 216 | 208 | 112,6 | 22 | 87,2  | 96,6 |
| Nargiza F <sub>1</sub> | 1) Untreated (control)           | 191 | 184 | 87,5  | 19 | 59,0  | 96,3 |
|                        | 2). T-86, Bist at 1,0 ml/l water | 216 | 210 | 113,5 | 22 | 87,0  | 97,2 |
|                        | 3) T-86, Bist at 1,5ml/l water   | 258 | 250 | 113,4 | 26 | 104,0 | 96,9 |
|                        | Average by Factor A              | 222 | 215 | 104,8 | 22 | 83,3  | 96,7 |
| Average (by Factor B)  | 1) Untreated (control)           | 191 | 183 | 92,7  | 19 | 63,0  | -    |
|                        | 2). T-86, Bist at 1,0 ml/l water | 220 | 213 | 120,3 | 22 | 93,9  | -    |
|                        | 3) T-86, Bist at 1,5 ml/l water  | 247 | 240 | 116,7 | 25 | 102,1 | -    |

Maximum efficiency in high yield was achieved with Abadiya F<sub>1</sub>. When treated with T-86 and Bist at 1.5 ml/l of water, the productivity per plant reached 2,929.9 g, consisting of an average of 27 fruits. The biological yield was 104.2 t/ha, which was 45.1 t/ha higher than the control variant. Marketable yield stood at 101.4 t/ha, representing a surplus of 44.0 t/ha over the control and a marketability rate of 96.9%. In the case of lower dosage applications, the marketable yield surplus relative to the control was 17.0 and 16.7 g.

The research results showed no changes in fruit color based on the concentration of stimulants. The fruit skin across all variants was characterized by uniform color and structure. No spots or blemishes were observed. The average visual appearance score was 4.7–4.8 points.

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The fruit flavor was pleasant and sweet, with uniform acidity levels. Organoleptic properties were rated at 4.7 points. The external appearance of the fruits was standard, being glossy, defect-free, and fully consistent with botanical indicators. It was observed that when sweet peppers were provided with foliar nutrition at a concentration of 1 ml of preparation per 1 liter of water, the fruit firmness was 0.5–0.6 g/cm<sup>2</sup> higher than that of the control (Table 2).

### Mechanical Strength and Dry Matter Content of Pepper Fruits (Average for 2022–2024)

| Variety                | Treated variant (Factor-B)       | Mechanical strength of fruit (g/cm <sup>2</sup> ) |           | Dry matter content % |
|------------------------|----------------------------------|---|-----------|----------------------|
|                        |                                  | 8 mm tip  | 11 mm tip |                      |
| Gemini F <sub>1</sub>  | 1) Untreated (control)           | 4,9   | 5,7       | 4,2                  |
|                        | 2). T-86, Bist at 1,0 ml/l water | 5,0   | 6,3       | 5,8                  |
|                        | 3). T-86, Bist at 1,5 ml/l water | 5,1   | 6,4       | 5,5                  |
|                        | Average by Factor B              | 5,0   | 6,1       | 5,2                  |
| Abadiya F <sub>1</sub> | 1) Untreated (control)           | 4,8   | 5,7       | 3,8                  |
|                        | 2). T-86, Bist at 1,0 ml/l water | 5,8   | 6,5       | 5,8                  |
|                        | 3). T-86, Bist at 1,5 ml/l water | 5,2   | 5,9       | 5,6                  |
|                        | Average by Factor B              | 5,3   | 6,0       | 5,1                  |
| Nargiza F <sub>1</sub> | 1) Untreated (control)           | 5,1   | 6,1       | 4,0                  |
|                        | 2). T-86, Bist at 1,0 ml/l water | 5,3   | 6,5       | 5,5                  |
|                        | 3). T-86, Bist at 1,5 ml/l water | 5,1   | 6,5       | 5,7                  |
|                        | Average by Factor B              | 5,2   | 6,4       | 5,1                  |
| Average (by Factor A)  | 1) Untreated (control)           | 4,9   | 5,8       | 4,0                  |
|                        | 2). T-86, Bist at 1,0 ml/l water | 5,4   | 6,4       | 5,7                  |
|                        | 3). T-86, Bist at 1,5 ml/l water | 5,1   | 6,3       | 5,6                  |

In the experimental variant with the Abadiya F<sub>1</sub> hybrid, this indicator ranged from 5.8 to 6.5 g/cm<sup>2</sup>. Regardless of the variety, the mechanical strength of the pepper fruits increased to 5.1–5.4 g/cm<sup>2</sup>, and when tested with a 10 mm tip, it reached 6.3–6.4 g/cm<sup>2</sup>.

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The dry matter content in the pepper fruits increased by approximately 1.6–1.7% depending on the concentration of the preparations used for nutrition.

The harvested sweet pepper fruits were stored in clean, dry, cooled, and odorless conditions. After one week, the number of sweet pepper fruits reaching technical maturity across the experimental variants increased on average from 13.3% to 25%, while biological maturity increased from 50% to 86.7%. By the third week, full ripening of the fruits was observed regardless of the treatment variant applied.

Research results demonstrated that the highest economic efficiency was achieved when T-86 and Bist preparations were dissolved at a concentration of 1.5 ml/l of water and applied to the Nargiza F<sub>1</sub> variety (Table 3).

### Economic Efficiency of Pepper Variety Cultivation (Average for 2022–2024)

| Variety                | Variants                        | Total production costs (UZS/ha) | Price of sold product (thousand UZS/t) | Net profit (thousand UZS/ha) | Economic efficiency (calculated as UZS earned per UZS spent) |
|------------------------|---------------------------------|---------------------------------|--|------------------------------|--|
| Gemini F <sub>1</sub>  | 1).Untreated (control)          | 65,5                            | 274,7                                  | 209,2                        | 560,0  |
|                        | 2).T-86, Bist at 1,0 ml/l water | 69,4                            | 396,7                                  | 326,6                        | 798,0  |
|                        | 3).T-86, Bist at 1,5 ml/l water | 69,9                            | 407,0                                  | 337,1                        | 812,0  |
| Abadiya F <sub>1</sub> | 1).Untreated (control)          | 64,5                            | 248,6                                  | 184,1                        | 532,0  |
|                        | 2).T-86, Bist at 1,0 ml/l water | 69,3                            | 393,5                                  | 324,2                        | 798,0  |
|                        | 3).T-86, Bist at 1,5 ml/l water | 70,1                            | 418,3                                  | 348,2                        | 840,0  |
| Nargiza F <sub>1</sub> | 1).Untreated (control)          | 64,3                            | 239,4                                  | 175,1                        | 518,0  |
|                        | 2).T-86, Bist at 1,0 ml/l water | 67,5                            | 354,0                                  | 286,6                        | 742,0  |
|                        | 3).T-86, Bist at 1,5 ml/l water | 70,4                            | 424,2                                  | 353,8                        | 840,0  |

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In this case, the value of the sold products amounted to 181,000,000 UZS/t, with economic efficiency at 9,000,000 UZS and total costs totaling 71,000,000 UZS/ha. For the sweet pepper, the price was 44,000,000 UZS and the total profit equaled 60,000,000 UZS, which was less than that of the Nargiza F<sub>1</sub> variety. However, the level of economic efficiency reached 60,000,000 UZS. Total costs for Abadiya F<sub>1</sub> were 75,000,000 UZS/ha, with a sales difference of 12,000,000 UZS. Compared to the Gemini F<sub>1</sub> variety, this was 15,000,000 UZS less. The level of net profit across other varieties varied by 12,000,000–17,000,000 UZS/ha. Economic efficiency in terms of expenditures amounted to 9,000,000 UZS.

In conclusion, when sweet pepper crops were provided with foliar nutrition at a concentration of 1.5 ml/l of water, the total yield for the Nargiza F<sub>1</sub> variety increased by 44 t/ha compared to the control, while for the Abadiya F<sub>1</sub> and Gemini F<sub>1</sub> varieties, the increases were 4.1 t/ha and 1.4 t/ha, respectively.

On average across the varieties, the application of T-86 and Bist preparations dissolved at 1.5 ml/l of water resulted in a noteworthy additional yield of 38.3 tons compared to the control. When the preparations were applied at 1 ml/l of water, the fruit yield decreased by 8.2 t/ha relative to the higher concentration mentioned above.

The highest net profit was achieved through three cycles of plant nutrition combined with the application of preparations via drip irrigation. At a concentration of 1.5 ml/l of water, profits ranged from 36,000,000 UZS/ha to 38,000,000 UZS/ha, depending on the variety. Compared to the control, variants where the preparations were applied showed an increase of 15,000,000 UZS/ha to 18,000,000 UZS/ha. Furthermore, in the 1 ml/l concentration variants, additional income of 12,000,000 UZS/ha and 7,200,000 UZS was obtained. The maximum income among these results was observed in the Nargiza F<sub>1</sub> variety.

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