

Article

The Effect of Growing Sweet Pepper under Shading Nets in Dry Subtropical Conditions on Yield and Fruit Quality Indicators

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Abstract: This article presents the results of a study on the effectiveness of growing sweet pepper varieties under shading nets in the dry subtropical conditions of Uzbekistan. The study evaluated important economically and biologically relevant traits of the Nargiza, Tong, and Dar Tashkenta varieties grown in open-field conditions and under shading nets, including fruit weight, length, diameter, wall thickness, total yield, and marketable yield. The results showed that growing sweet pepper under shading nets increased fruit weight and size, fruit wall thickness, and yield parameters in all studied varieties. Under shading nets, fruit weight increased by 18.4 g in the Nargiza variety, by 16.0 g in the Tong variety, and by 18.0 g in the Dar Tashkenta variety. Total yield increased by 6.9 t/ha, 7.5 t/ha, and 5.8 t/ha, respectively. The marketability of the yield increased by 20.0–28.0% across the varieties, reaching 94.6–95.5%. The results demonstrate that the use of shading nets in sweet pepper cultivation contributes to increased yield and improved quality of the resulting produce.

Keywords: sweet pepper, shading net, open-field conditions, fruit weight, fruit diameter, fruit wall thickness, total yield, marketable yield, marketability of yield, dry subtropical conditions.

Introduction

Sweet pepper (*Capsicum annuum* L.) occupies an important place among vegetable crops, and increasing its yield and improving fruit quality are among the major objectives of cultivation technology. Plant productivity depends not only on the biological characteristics of the variety but also directly on agroclimatic conditions during the growing period, as well as on the agrotechnical practices applied. In particular, when growing sweet pepper under dry subtropical conditions, it is of particular importance to create optimal growing conditions that ensure normal plant growth, fruit formation, and the production of high-quality yields.

Under dry subtropical conditions, growing sweet pepper requires consideration of the influence of environmental factors to ensure the full expression of the productive potential of the varieties. The effect of the cultivation method on fruit formation is reflected in such important parameters as fruit weight, length, diameter, and wall thickness. Therefore, evaluating modern agrotechnical methods that can create relatively favorable conditions for plant growth and

development directly under production conditions is one of the relevant scientific and practical objectives.

The use of shading nets in sweet pepper cultivation is considered one of the methods aimed at protecting plants and fruits from direct exposure to intense solar radiation, as well as improving crop quality. In the conducted studies, the Nargiza, Tong, and Dar Tashkenta varieties were grown under open-field conditions and under shading nets, while the effects of these cultivation methods on fruit morphological characteristics and yield were evaluated.

In a study by Aied K. Y. et al. (2023), the effect of shading on the growth and yield of sweet pepper and eggplant under high summer temperatures was investigated. According to the results obtained, the application of shading for two months reduced the effects of intense solar radiation and heat stress, which positively affected plant growth and yield. The authors concluded that the use of shading materials during hot summer periods is an effective agrotechnical practice for increasing the yield of pepper and eggplant [1]. Mohawesh O. et al. (2022) investigated the effects of white, green, and black shading nets with a 50% shading level on sweet pepper under semi-arid climatic conditions. According to the results obtained, the use of shading nets reduced air temperature from 32–37 °C to 22–28 °C and light intensity from 24,973 lux to 9,992 lux. Compared with the control, the use of shading nets improved plant growth and increased leaf chlorophyll content, vitamin C content, photosynthetic rate, and water-use efficiency. The results demonstrated that green and black shading nets are effective for sweet pepper cultivation under semi-arid climatic conditions [2]. Zoran S. Ilić et al. (2025) established in their studies that colored shading nets have a positive effect on plant growth and fruit quality of sweet pepper. At a shading level of 40%, the best results were obtained with red and white shading nets. Under these conditions, an increase in fruit flesh thickness was observed, while the vitamin C content reached 175.77 mg/100 g. In addition, it was established that the application of these shading nets protects plants from intense solar radiation and represents an effective agrotechnical practice for improving product quality and increasing yield [3]. Ambrózy Z. S., Daood H. et al. (2015), based on the results of their studies, established that photoselective nets of different colors alter the microclimate of the sweet pepper growing environment and have a positive effect on plant productivity and the biochemical composition of fruits. At a shading level of 40%, the yield obtained using a yellow shading net was 33.6 t/ha, whereas this indicator was 15.5 t/ha in the control treatment. In addition, it was established that the use of certain types of shading nets reduces plant and fruit damage caused by solar radiation and creates favorable conditions for increasing carotenoid content [4]. According to the research results of Juan Carlos Díaz-Pérez (2013), the use of shading nets contributes to improved growth processes and adaptation of sweet pepper to environmental conditions. The experiment investigated shading levels of 0%, 30%, 47%, 62%, and 80%, with 30–47% shading providing the most favorable conditions for plant growth and development. As the shading level increased, an increase in leaf area, individual leaf size, and the content of mineral elements (N, K, Ca, Mg, Mn, S, Al, and B) was observed. However, at high shading levels of 62–80%, a decrease in photosynthetic rate was observed. The results demonstrated that moderate shading is the most effective approach for sweet pepper cultivation to reduce the effects of high temperatures and stabilize the physiological processes of plants [5]. According to Juan Carlos Díaz-Pérez, Kelly St. John et al. (2020), the reduction in leaf temperature of sweet pepper plants grown under colored shading nets, regardless of their color, plays an important role in improving plant growth and quality. The authors consider that the use of shading nets contributes to reducing plant water stress, which is associated with lower evaporative demand compared with sweet pepper grown under conventional open-field conditions [6].

Research Methods

The study objects comprised three sweet pepper varieties: Nargiza, Tong, and Dar Tashkenta. The experiment was conducted with four replications. The area of the experimental plot was 8.4 m². The planting scheme was 70 × 25 cm. Each plot consisted of two rows, with a plot width of 1.4 m and a length of 6 m. A total of 48 plants were grown on each plot.[7]

During the growing season, phenological observations were conducted, morphological and biological characteristics of the plants were described, and the main economically and biologically

relevant parameters were determined. Harvesting was carried out separately for each replication, after which the harvested produce was weighed and yield indicators were calculated. The morphological characteristics of the fruits, including fruit length, diameter, wall thickness, individual fruit weight, and the total fruit weight obtained from a single plant, were determined.[8]

Calculations were performed separately for each replication, and the data obtained during the experiment were subjected to statistical analysis according to the methodology of B. A. Dospekhov (1985). The contents of dry matter, sugars, and vitamin C were also determined in the sweet pepper fruits under study.

Phenological observations were conducted according to the following developmental stages: sowing; emergence, recorded when 10% and 75% of seedlings had emerged; onset of flowering, determined by the opening of flowers on 10% of the plants; full flowering, recorded when flowers had opened on 75% of the plants; and technical maturity of fruits, determined when the fruits reached the characteristic size and condition of the respective variety and were suitable for consumption.[9]

Measurements were conducted for the following morphological and biological traits: plant height, cm; plant diameter, cm; number of first-order branches, units; fruit length, cm; fruit diameter, cm; fruit wall thickness, mm; fruit shape; fruit color; biochemical composition; and individual fruit weight, g.[10]

These measurements were carried out on 50% of the plants when the fruits reached technical maturity, before the first harvest. The morphological and biological parameters were determined on 20 plants of each variety. The morphological characteristics of the fruits were determined using 20 typical fruits selected from each variety.

Results

At the technical maturity stage, the average fruit weight of the Nargiza variety grown under shading nets was 88.4 g, whereas under open-field conditions it was 70.0 g. Thus, cultivation under shading nets resulted in an increase in fruit weight of 18.4 g, or 26.3%.p[11]

In the Tong variety, fruit weight under shading nets was 70.0 g, compared with 54.0 g under open-field conditions. Growing under shading nets increased the fruit weight of this variety by 16.0 g, or 29.6%, compared with open-field cultivation.

In the Dar Tashkenta variety, fruit weight at the technical maturity stage was 84.0 g when grown under shading nets, whereas under open-field conditions it was 66.0 g. The application of shading nets resulted in an increase in fruit weight of 18.0 g, or 27.3%.[12]

Growing sweet pepper under shading nets also had a positive effect on fruit length and diameter.

When grown under shading nets, the fruits of the Nargiza variety were 1.6 cm longer and 1.2 cm larger in diameter compared with plants grown under open-field conditions. In the Tong variety, growing under shading nets increased fruit length by 0.7 cm and fruit diameter by 0.3 cm compared with open-field cultivation.

Table 1. Characteristics of Sweet Pepper Fruits Grown under Open-Field Conditions and Shading Nets 2024–2026

№	Variety samples	Cultivation method	Fruit							
			Weight, g	Color	Shape	Length, cm	Diameter, cm	Index	Wall thickness, mm	Position on the plant
1	Nargiza	I*	70,0	Light green	Conical	8,6	5,1	1,7	4,2	Downward-oriented
		II*	88,4	Light green	Conical	10,2	6,3	1,6	5,1	Downward-oriented

2	Tong	I	54,0	Light green	Pyramidal	9,9	4,0	2,5	3,5	Upward-oriented
		II	70,0	Light green	Pyramidal	10,6	4,3	2,5	4,1	Upward-oriented
3	Dar Tashkenta	I	66,0	Light green	Conical	10,2	5,4	1,9	4,4	Downward-oriented
		II	84,0	Light green	Conical	11,3	6,2	1,8	5,2	Downward-oriented

Note: I – cultivation under open-field conditions (control)

II – cultivation under shading nets

When the Dar Tashkenta variety was grown under shading nets, fruit length was 11.3 cm, which was 1.1 cm greater than under open-field conditions. Fruit diameter was 6.2 cm, representing an increase of 0.8 cm compared with open-field cultivation.[13]

Growing under shading nets had a pronounced positive effect on the fruit size of the Nargiza variety. The Tong and Dar Tashkenta varieties also showed a positive response to this cultivation method in terms of fruit size; however, the magnitude of the effect was somewhat lower compared with the Nargiza variety.

One of the most important indicators is fruit wall (pericarp) thickness. The research results showed that cultivation methods also affect fruit wall thickness. In particular, in the Nargiza variety, fruit wall thickness under open-field conditions was 4.2 mm, whereas under shading nets this parameter reached 5.1 mm, which was 0.9 mm greater than under open-field conditions.[14]

In the Tong variety, this parameter was somewhat lower: under open-field conditions, fruit wall thickness was 3.5 mm, whereas under shading nets it was 4.1 mm, representing an increase of 0.6 mm compared with open-field cultivation. In the Dar Tashkenta variety, fruit wall thickness under open-field conditions was 4.4 mm, while under shading nets this parameter reached 5.2 mm. Thus, compared with open-field conditions, fruit wall thickness increased by 0.8 mm.[15]

The cultivation methods had practically no effect on plant type, fruit position on the plant, or fruit shape. The fruit color of all three studied varieties was also light green, with the cultivation method having practically no effect on this trait. However, fruits grown under shading nets exhibited a brighter and more attractive color. In addition, the fruits were not affected by sunburn and developed in accordance with the characteristic varietal traits. This contributed to an increase in the marketability of the yield.

Table 2. Yield of Sweet Pepper Varieties Grown under Open-Field Conditions and Shading Nets 2024–2026

№	Variety samples	Cultivation method	Total yield		Marketable yield		Marketability of the yield , %
			t/ha	Compared with the control , %	t/ha	Compared with the control , %	
1	Nargiza	I	43,8	100	40,4	100	92,4
		II	50,7	116	48,5	120	95,5
2	Tong	I	38,2	100	34,0	100	89,0
		II	45,7	120	43,3	128	94,9
3	Dar Tashkenta	I	40,1	100	37,9	100	94,4
		II	48,6	121	46,0	121,3	94,6

The primary expected outcome of any agrotechnical practice is an increase in yield and an improvement in the quality of the resulting produce.

Growing sweet pepper under shading nets contributed to increased yield and improved product quality (see Table 2). The highest total yield for all three studied varieties was obtained under shading-net cultivation.

HCP ₀₅	3,1	3,5
S _{x%}	4,1	3,7

When the Nargiza variety was grown under open-field conditions, the total yield was 43.8 t/ha, whereas under shading nets this indicator reached 50.7 t/ha. Thus, growing under shading nets increased the yield by 6.9 t/ha, or 15.8%.

When the Tong variety was grown under open-field conditions, the total yield was 38.2 t/ha, whereas under shading nets it reached 45.7 t/ha. Thus, growing under shading nets increased the yield by 7.5 t/ha, or 19.6%.

When the Dar Tashkenta variety was grown under open-field conditions, the total yield was 40.1 t/ha, whereas under shading nets this indicator reached 48.6 t/ha. In other words, growing under shading nets increased the yield by 8.5 t/ha, or 21%.

Marketable yield was also significantly higher when grown under shading nets compared with open-field cultivation.

In the Nargiza variety, marketable yield under open-field conditions was 40.4 t/ha, whereas under shading nets it was 48.5 t/ha. Thus, compared with open-field cultivation, growing under shading nets increased marketable yield by 8.1 t/ha, or 20%. In the Tong variety, the corresponding values were 38.2, 45.7, and 8.1 t/ha, respectively, with an increase of 28%, while in the Dar Tashkenta variety, the corresponding values were 37.9, 46.0, and 8.1 t/ha, respectively, with an increase of 21.3%.

The marketability of the yield was also higher under shading nets compared with open-field cultivation.

In the Nargiza variety grown under open-field conditions, the marketability of the yield was 92.4%. At the same time, fruits affected by sunburn, damaged by high temperatures, and remaining small accounted for 7.6%. Under shading nets, the proportion of marketable fruits increased by 3.1% and reached 95.5%.

Conclusion

Growing sweet pepper varieties under shading nets under dry subtropical conditions had a positive effect on improving fruit quality indicators compared with open-field cultivation. When grown under shading nets, the Nargiza, Tong, and Dar Tashkenta varieties exhibited higher values for fruit weight, length, diameter, and fruit wall thickness.

Higher yield results were also obtained in the variants grown under shading nets. The total yield was 50.7 t/ha for the Nargiza variety, 45.7 t/ha for the Tong variety, and 48.6 t/ha for the Dar Tashkenta variety. Compared with open-field cultivation, the yield increased by 15.8%, 19.6%, and 21%, respectively.

Higher marketable yield and marketability of the yield were also obtained when the plants were grown under shading nets. In the Nargiza variety, marketable yield was 48.5 t/ha, while the marketability of the yield was 95.5%. Overall, the research results demonstrated that growing sweet pepper varieties under shading nets under dry subtropical conditions contributes to increased yield and improved fruit quality.

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