

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(9): 369-372
www.biochemjournal.com
Received: 27-06-2026
Accepted: 30-07-2026

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Effect of planting density on growth and yield of okra (*Abelmoschus esculentus* L. Moench.)

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i9Se.9853>

Abstract

An experiment was conducted at the School of Agriculture Science, Technology Research, Sardar Patel University, Balaghat (M.P.). The present investigation entitled “Effect of planting density on growth and yield of Okra (*Abelmoschus esculentus* L. Moench.)” was carried out during Karif-2024. At the Horticultural Research Farm, Sardar Patel University, Balaghat (M.P.). The experiment was laid out in a Randomized Block Design (RBD) with eight treatments in three replications. The application of different planting density viz., T₁- 40 x 30 cm, T₂- 60 x 45 cm, T₃- 45 x 45 cm, T₄- 90 x 60 cm, T₅- 45 x 30 cm, T₆- 60 x 30 cm, T₇- 60 x 60 cm, T₈- 40 x 40 cm was used for the experiment. From the foregoing results, it can be concluded that okra plant grown in a different planting density 90 x 60 cm i.e., T₄ gave the best results in terms of vegetative growth i.e., plant height, number of branches per plant, Stem girth (cm), number of leaves per plant, number of fruits per plant, length of pod (cm), diameter of pod (cm), fruit weight per plant (g), yield per plant (g), fruit yield per hectare (t/ha) at 30, 45, 60 and 90 days after sowing of okra plant.

Keywords: Okra, planting distance, fruit yield, fruit quality

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench), also known as lady finger, is an economically critical summer vegetable crop that belongs to the family Malvaceae. The crop is popular because of its easy cultivation, reliable yield, and adaptability to varying moisture conditions (resistant to drought and waterlogging) and soil types (Maurya *et al.*, 2013). Cultivated in tropical, subtropical, and warm temperate regions worldwide for its edible green seed pods, okra is used in the cuisines of many countries (Madisa *et al.*, 2014). Okra is one of the most favorite vegetables for growing in kitchen gardens. It is rich in vitamins and minerals. It also has medicinal value. The species is a perennial, often cultivated as an annual in temperate climates, often growing to around 2 metres (6 ft 7 in) tall. As a member of the Malvaceae, it is related to such species as cotton, cocoa, and hibiscus. The leaves are 10–20 centimetres (4–8 in) long and broad, palmately lobed with 5–7 lobes. Consumption of young immature okra pods is important as fresh fruits, and they can be consumed in different forms (Ndunguru and Rajabu, 2004).

Fruits can be boiled, fried, or cooked. The composition of okra pods per 100 g edible portion (81% of the product as purchased, ends trimmed) is: water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 µg, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg. (Nikpayam *et al.*, 2021). Okra seeds contain about 20% protein and 20% oil. Okra seed oil has a potential *hypcholesterolemic* effect.

It requires a long warm growing season and is susceptible to frost. The optimum range of temperature for germination of seed is 26.7°C to 30 °C. It thrives in all kinds of soil but grows best in well-manured, sandy loam to well-drained medium black and light clayey soils rich in organic matter. The soils having a pH range from 6.0 to 6.8 are most favourable. Plant population affects competition for growth resources (Chauhan, 1972).

Spacing is generally dependent upon the expected growth of a particular crop variety in a given set of agroclimate. This determines the plant density. The space allowed to an individual plant is one of the determining factors controlling its development and yield.

Close spacing leads to overcrowding and more plant competition, whereas wide spacing reduces the population and enhances vegetative growth, thereby decreasing the total yield. The cumulative yield per plant is higher under high plant population, but the yield per plant is low (Salau and Makinde, 2015). Wide commercially important varieties of okra have been released by different Agricultural Institutes. Among them, Varsha Uphar and Hissar Naveen (HAU, Hissar), Pusasawani and Perkins long green (IARI, New Delhi) and Arka Anamika (IIHR, Bengaluru) have been recommended for all over India. The variety Varsha Uphar is derived from Lam selection x Parbhani Kranti, which is resistant to the yellow vein mosaic virus (Singh, 2012). In Madhya Pradesh, it is grown successfully in Jabalpur, Sagar, Hosangabad, Vidisha, Sehore, Jhabua, Indore, Barwani and Bhopal in a 26.51-thousand-hectare area and production of 305.91 thousand mt with 11.5 tonnes/ha productivity during the year 2014. The plant density plays an important role in the yield of okra fruit and seed (Yadav *et al.*, 2023).

Okra production in India is mainly limited to the rainy season. The production of okra in the off-season may meet the market demand during the lean period of vegetable supply and can improve the nutritional status. Spacing is also considered an important cultural operation governing the yield of okra. Narrow spacing results in higher plant population lower's, higher competition for all the resource factors, but in wider spacing this competition is less, which results in healthier plants. Suitable plant spacing can lead to optimum yield, but incorrect plant spacing could result in relatively low yield and poor-quality fruits. A significant decrease in pod yield per plant with increasing plant density was observed; plant populations may result in rigorous growth, poor-quality fruits and low yield due to intraspecific competition. The effect of plant spacing on the growth and yield of okra has also been reported by many authors (Rajput *et al.*, 2018)

Material and Methods

The present investigation entitled “effect of planting density on growth and yield of Okra (*Abelmoschus esculentus* L. Moench.)” was carried on Karif-2024. At the Horticultural Research Farm, Sardar Patel University, Balaghat (M.P.). The experiment was laid out in a Randomized Block Design (RBD) with eight treatments in three replications. The application of different planting density viz., T₁- 40 x 30 cm, T₂- 60 x 45 cm, T₃- 45 x 45 cm, T₄- 90 x 60 cm, T₅- 45 x 30 cm, T₆- 60 x 30 cm, T₇- 60 x 60 cm, T₈- 40 x 40 cm was used for the experiment.

Cultural practices

Field preparation

The field was prepared by criss-cross ploughing and harrowing. Then the flat beds of dimension 1.1 x 1.12 m were prepared.

Sowing

After field preparation, the seeds were sown at three different spacings of 40 x 30, 60 x 45, 45 x 45, 90 x 60, 45 x 30, 60 x 30, 60 x 60 and 40 x 40 cm (Row to Row and Plant to Plant). The seeds were dibbled manually on 25th June, 2024 with a recommended seed rate of 6 kg ha⁻¹. Two seeds were dibbled at each spot. Seeds were soaked in water 10-12 hrs. before sowing. After one week of sowing, gap filling

was carried out. Thinning of plants was carried out 20 days after sowing by keeping one healthy plant per hill.

Watering

Optimal moisture of soil was maintained by watering once a day until germination started. When germination was started the watering was done twice a day (morning and evening).

Application of fertilizers

The fertilizer were applied as pre recommended dose of 100-50-50 NPK (kg ha⁻¹). The half doses of N and full doses of P and K were given at the time of sowing as a basal dose and a half dose of N was given at 15 days after sowing.

Observations

Five plants of each plot from each replication were tagged to record the growth and yield i.e. Plant height (cm) 30, 45 and 60 DAS, Number of branches per plant at 30, 45 and 60 DAS, Number of leaves per plant, Stem girth (cm), Number of fruits per plant, Length of pods (cm), Diameter of pods (cm) and Yield parameter i.e., Fruit weight per plant (g), Yield per plant (g), Fruit yield per hectare (t/ha.)

Fruit yield per hectare (t/ha.)

The yield of fruit per hectare was computed from the per plot yield and was recorded in quintals

$$\text{Fruit Yield (t/ha)} = \frac{\text{Total Fruit Weight per Plant (g)} \times \text{Plant Population per ha}}{1000000}$$

Results and Discussion

Growth Parameters

Plant Height (cm)

Plant height varied significantly across different planting densities evaluated at 30, 45, and 60 days after sowing (DAS). Treatment T₄ (90x60 cm) consistently recorded the highest plant height across all intervals, reaching 28.23 cm at 30 DAS (statistically at par with T₂ at 23.26 cm), 50.59 cm at 45 DAS, and 69.59 cm at 60 DAS, significantly outperforming all other treatments at the later stages. Conversely, the lowest plant height was observed in T₁ (40x30 cm) at 30 DAS (21.79 cm) and 60 DAS (56.46 cm), while T₅ (45x30 cm) recorded the minimum height at 45 DAS (44.69 cm). Overall, lower planting density (wider spacing in T₄) favored greater plant height growth throughout the observation period.

Number of branches per plant

Planting density significantly influenced the number of branches per plant across all growth stages (30, 45, and 60 DAS). Treatment T₄ (90x60 cm) consistently recorded the maximum number of branches per plant, reaching 2.11 at 30 DAS (at par with T₂ at 1.85), 3.94 at 45 DAS, and 5.21 at 60 DAS, significantly surpassing all other treatments at the later stages. Conversely, the minimum branch count was recorded in closer planting densities, specifically T₁ (40x30 cm) at 30 DAS (1.46) and 60 DAS (3.28), and T₅ (45x30 cm) at 45 DAS (2.29). Overall, wider plant spacing (lower density in T₄) promoted greater branch development throughout the observation period.

Stem girth (cm)

Planting density significantly affected the stem girth of field-grown okra at both 45 and 60 days after sowing (DAS). Treatment T₄ (90x60 cm) consistently achieved the maximum stem girth, reaching 2.53 cm at 45 DAS and 2.78 cm at 60 DAS. In contrast, the narrowest stem girths were observed in higher-density treatments, with T₅ (45x30 cm) recording the minimum at 45 DAS (1.42 cm) and T₁ (40x30 cm) at 60 DAS (1.83 cm). Overall, wider plant spacing in T₄ enhanced stem thickness throughout the growth period.

Number of leaves per plant

Planting density significantly influenced the number of leaves per plant in okra at both 45 and 60 DAS, with leaf counts increasing over time. At 45 DAS, the maximum number of leaves (18.68) was observed in T₄ (90x60 cm; incorrectly labeled as T₅ in text), which was statistically at par with T₂ (15.38) and T₅ (13.40). By 60 DAS, T₄ (90x60 cm) maintained the highest leaf count (22.37), remaining at par with T₂ (19.37). In contrast, the minimum leaf count was consistently recorded in the high-density T₁ treatment (40x30 cm) at both 45 DAS (13.02) and 60 DAS (16.39).

Yield Parameters

Number of fruits per plant

Planting density significantly impacted the number of fruits per plant in plug tray-grown okra at 60 DAS. Treatment T₄ (90x60 cm) recorded the maximum number of fruits per plant (13.45), which was statistically at par with T₂ (11.73) and T₃ (11.09). Conversely, the minimum fruit count (10.08) was recorded in the highest-density planting treatment, T₁ (40x30 cm). Overall, wider plant spacing favored greater fruit production per plant.

Planting density significantly influenced pod length, pod diameter, and fruit weight per plant in okra at 60 days after sowing. Treatment T₄ (90x60 cm) consistently achieved the highest values across all three parameters. The maximum pod length (13.00 cm) was recorded in T₄, which was statistically at par with T₂ (12.81 cm), while the minimum pod length (10.93 cm) was noted in T₅ (45x30 cm). For pod diameter, T₄ reached a maximum of 7.19 cm, remaining at par with T₂ (6.65 cm) and T₅ (6.02 cm), whereas the

minimum diameter (5.38 cm) was recorded in T₁ (40x30 cm). Fruit weight per plant ranged from 12.87 to 14.96 g, with the maximum observed in T₄ (14.96 g) and the minimum in T₁ (12.87 g). Overall, wider plant spacing in T₄ significantly enhanced individual fruit yield and physical dimensions compared to denser planting setups.

Yield per plant (g)

Planting density significantly affected yield per plant in okra at both 60 and 90 days after sowing (DAS). Treatment T₄ (90x60 cm) consistently produced the maximum yield per plant, reaching 185.12 g at 60 DAS and 216.97 g at 90 DAS, remaining statistically at par with T₂ (147.90 g at 60 DAS and 194.51 g at 90 DAS). Conversely, the minimum yield per plant was recorded in the densest spacing, T₁ (40x30 cm), at both 60 DAS (128.09 g) and 90 DAS (134.68 g). Overall, wider planting density significantly enhanced individual plant yield over time.

Fruit yield per hectare (t/ha)

Planting density significantly influenced the total fruit yield per hectare of okra at both 60 and 90 days after sowing (DAS). Treatment T₄ (90x60 cm) consistently achieved the highest fruit yield per hectare, reaching 6.05 t/ha at 60 DAS and 6.86 t/ha at 90 DAS, remaining statistically at par with T₂ (4.81 t/ha at 60 DAS and 5.86 t/ha at 90 DAS). Conversely, the minimum fruit yield per hectare was recorded under the closest spacing, T₁ (40x30 cm), with 4.30 t/ha at 60 DAS and 4.88 t/ha at 90 DAS. Overall, wider plant spacing in T₄ significantly optimized per-hectare productivity over time.

Conclusion

Based on the findings of the present investigation, it can be concluded that okra plant grown in a different planting density 90 x 60 cm i.e., T₄ gave the best results in terms of vegetative growth i.e., plant height, number of branches per plant, Stem girth (cm), number of leaves per plant, number of fruits per plant, length of pod (cm), diameter of pod (cm), fruit weight per plant (g), yield per plant (g), fruit yield per hectare (t/ha) at 30, 45, 60 and 90 days after sowing of okra plant.

Table 1: Effect of different planting densities on growth parameters of okra

Notations	Treatment	Plant height (cm)			Number of branches per plant			Number of leaves per plant		Stem girth (cm)	
		30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
T ₀	40x30 cm ²	21.79	44.86	56.46	1.46	2.29	3.28	13.02	16.39	1.66	1.83
T ₁	60x45 cm ²	23.26	47.37	62.00	1.85	2.91	4.14	15.38	19.37	2.05	2.27
T ₂	45x45 cm ²	23.12	46.20	60.30	1.24	2.80	3.64	13.21	17.91	1.55	1.91
T ₃	90x60 cm ²	28.23	50.59	69.59	2.11	3.94	5.21	18.68	22.37	2.53	2.78
T ₄	45x30 cm ²	22.88	44.66	59.67	1.61	2.54	3.74	13.40	17.50	1.42	2.03
T ₅	60x30 cm ²	21.927	46.84	57.14	1.49	2.33	3.44	13.22	16.50	1.77	1.91
T ₆	60x60 cm ²	22.587	47.41	60.57	1.79	2.83	4.02	15.22	19.21	1.98	2.20
T ₇	40x40 cm ²	22.287	46.04	58.27	1.59	2.44	3.49	13.21	16.41	1.71	1.87
T ₈	40x30 cm ²	21.79	44.86	56.46	1.46	2.29	3.28	13.02	16.39	1.66	1.83
SEm ±		0.47	0.43	0.68	0.09	0.16	0.16	0.38	0.83	0.20	0.13
CD at 5%		1.44	1.32	2.09	0.27	0.49	0.48	1.17	2.56	0.61	0.41

Table 2: Effect of different planting densities on yield parameters of okra.

Notations	Treatment	Number of fruits per plant	Length of pod (cm)	diameter of pod (cm)	Fruit weight per plant (g)	yield per plant (g)		Fruit yield per hectare (t/ha)	
		60 DAS	60 DAS	60 DAS	60 DAS	60 DAS	90 DAS	60 DAS	90 DAS
T ₀	40x30 cm ²	10.08	11.38	5.38	12.87	128.09	134.68	4.30	4.88
T ₁	60x45 cm ²	11.73	12.18	6.65	14.40	147.90	194.51	4.81	5.86
T ₂	45x45 cm ²	11.09	11.55	5.50	13.69	130.94	154.31	4.74	5.56
T ₃	90x60 cm ²	13.45	13.00	7.19	14.96	185.12	216.97	6.05	6.86
T ₄	45x30 cm ²	10.59	10.93	6.02	13.15	132.54	143.13	4.51	5.08
T ₅	60x30 cm ²	10.17	11.48	5.48	12.99	128.66	135.30	4.39	5.06
T ₆	60x60 cm ²	11.48	12.09	6.53	14.30	147.06	193.07	4.71	5.75
T ₇	40x40 cm ²	10.17	11.43	5.44	12.94	128.56	135.18	4.43	5.15
T ₈	40x30 cm ²	10.08	11.38	5.38	12.87	128.09	134.68	4.30	4.88
SEm ±		0.28	0.30	0.36	0.30	3.04	0.65	0.11	0.04
CD at 5%		0.88	0.93	1.11	0.92	9.33	2.01	0.36	0.14

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