

## RESEARCH ARTICLE

## EFFECT OF CROP GEOMETRY AND IRRIGATION FREQUENCY ON YIELD AND RESOURCE USE EFFICIENCY OF OKRA UNDER DRIP IRRIGATION

Nayan Kumar<sup>1</sup>, Mukesh Kumar<sup>2\*</sup>, Ram Naresh<sup>2</sup>, Kapil<sup>2</sup>, Kuldeep Singh<sup>2</sup> and Amandeep Singh<sup>2</sup><sup>1,2</sup>Department of Soil and Water Engineering, CCS HAU, HisarEmail: [mukeshdandi@yahoo.com](mailto:mukeshdandi@yahoo.com)

Received-18.03.2026, Revised-13.04.2026, Accepted-28.04.2026

**Abstract:** A field experiment was conducted during the summer season at the research farm of CCS Haryana Agricultural University, Hisar, to evaluate the effects of crop geometry and irrigation frequency on yield, irrigation water use efficiency (IWUE), and fertilizer use efficiency (FUE) of okra (*Abelmoschus esculentus* L.). The experiment was arranged in a split-plot design with three replications. Two crop geometries were assigned to main plots: normal geometry (plant spacing 30 cm, row spacing 45 cm, and lateral spacing 45 cm with one lateral per crop row) and paired-row geometry (plant spacing 30 cm, paired rows at 30 cm with 90 cm spacing between pairs and one lateral for each pair of rows). Four irrigation frequencies viz. daily irrigation, alternate-day irrigation, irrigation after three days, and irrigation after five days—were allotted to subplots. Crop geometry and irrigation frequency significantly influenced yield and resource use efficiencies. Normal geometry with daily irrigation produced the highest total yield (114.98 q ha<sup>-1</sup>), IWUE (5.68 kg m<sup>-3</sup>), and FUE (54.76 kg kg<sup>-1</sup>), whereas the lowest values of yield (94.86 q ha<sup>-1</sup>), IWUE (4.68 kg m<sup>-3</sup>), and FUE (45.17 kg kg<sup>-1</sup>) were observed under paired-row geometry with irrigation after five days. Overall, normal geometry resulted in higher average yield (106.74 q ha<sup>-1</sup>) than paired-row geometry (102.85 q ha<sup>-1</sup>). Similarly, daily irrigation recorded the highest mean yield (113.86 q ha<sup>-1</sup>), IWUE (5.62 kg m<sup>-3</sup>), and FUE (54.22 kg kg<sup>-1</sup>), followed by alternate-day irrigation, irrigation after three days, and irrigation after five days.

**Keywords:** Irrigation water use efficiency, Fertilizer use efficiency, Paired row geometry

## INTRODUCTION

Water availability for agriculture is decreasing globally, making efficient irrigation management essential for sustainable crop production. Researchers are increasingly focusing on methods that can produce higher yields using less water. Drip irrigation has emerged as an effective irrigation technique because it delivers water directly to the root zone, thereby improving irrigation water use efficiency (IWUE) and crop productivity.

Okra (*Abelmoschus esculentus*), commonly known as lady's finger or "bhindi" in India, is an important vegetable crop cultivated in tropical and warm temperate regions. According to Gopalan *et al.* (1989), 100 g of edible okra contains 1.9 g protein, 0.2 g fat, 6.4 g carbohydrates, 0.7 g minerals and 1.2 g fibre. Okra also contributes significantly to vegetable exports and has considerable potential as a foreign exchange earning crop. In India, Gujarat contributes the highest share (15.89%) of okra production, followed by West Bengal (13.93%), whereas Haryana contributes about 2.86%. The total production of okra in India during 2021–22 was about 5445 thousand tonnes (National Horticulture Board, 2022).

Irrigation management plays a crucial role in the growth and productivity of okra. Soil type, crop type,

climatic condition, irrigation method and irrigation frequency are important factors affecting irrigation scheduling. Okra thrives under warm conditions but is sensitive to water stress, particularly during flowering and pod development stages. Studies have shown that frequent irrigation improves yield and water productivity in okra cultivation (Kumar *et al.*, 2016; Kumar *et al.*, 2023). Similarly, drip fertigation has been reported to save 20–61% water and increase yield by 13–76% compared with conventional irrigation methods (Sharma *et al.*, 2016).

Crop geometry is another important factor influencing crop growth and yield because it determines plant population, light interception, and efficient utilization of soil moisture and nutrients. Proper plant spacing allows better solar radiation interception and improves photosynthesis, ultimately enhancing crop productivity. Previous studies have indicated that wider spacing increases vegetative growth and yield per plant, whereas closer spacing increases yield per unit area (Ganjare *et al.*, 2013).

Although drip irrigation improves water use efficiency, its adoption is often limited due to the high initial cost, particularly the cost of lateral lines. Reducing the number of lateral lines by irrigating multiple crop rows with a single lateral can lower the system cost, but this may affect soil moisture distribution in the crop root zone. Modifying crop

\*Corresponding Author

geometry, such as paired row planting, along with appropriate irrigation frequency may help maintain adequate soil moisture distribution while reducing the cost of drip irrigation systems.

Therefore, keeping in view the interaction between crop geometry and irrigation frequency, the present study was undertaken to evaluate their effect on irrigation water use efficiency, fertilizer use efficiency and yield of okra.

## MATERIALS AND METHODS

### Study Area

The experiment was conducted at the field laboratory of the Department of Soil and Water Engineering, CCS Haryana Agricultural University, Hisar, India, during February to June 2025. The study was carried out in brick-lined microplots of 2 m × 2 m size equipped with a drip irrigation system.

### Soil Characteristics

Soil samples were collected from five randomly selected locations at 0–30 cm depth using a tube auger and mixed to form a composite sample for analysis. The soil of the experimental site was sandy loam in texture.

### Experimental Design and Treatments

The experiment was laid out in a split plot design with two crop geometries and four irrigation frequencies, replicated three times.

### Crop Geometry Treatments

- **G<sub>1</sub> – Normal geometry:** plant spacing 30 cm, row spacing 45 cm and lateral spacing 45 cm (one lateral per crop row).
- **G<sub>2</sub> – Paired row geometry:** plant spacing 30 cm, paired rows at 30 cm with 90 cm spacing between pairs (one lateral for each pair of rows).

### Irrigation Frequency Treatments

- **I<sub>1</sub> – Daily irrigation**
- **I<sub>2</sub> – Alternate day irrigation**
- **I<sub>3</sub> – Irrigation after three days**
- **I<sub>4</sub> – Irrigation after five days**

Thus, eight treatment combinations (G<sub>1</sub>I<sub>1</sub> to G<sub>2</sub>I<sub>4</sub>) were evaluated.

### Crop Management Practices

Before sowing, 25 kg farmyard manure (FYM) per plot along with the recommended dose of fertilizers was incorporated into the soil. The recommended fertilizer dose for okra was 100 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 50 kg K<sub>2</sub>O per hectare. Full doses of phosphorus and potassium and one-third of nitrogen were applied at sowing, while the remaining nitrogen was supplied through fertigation using the drip irrigation system.

Seeds of Hisar Unnat variety of okra were directly sown in the prepared plots on 25 February 2025. Gap filling was carried out after 10 days to maintain uniform plant population.

Weeds were controlled through regular hand weeding. During the experiment, pest infestation such as white fly and red-banded blister beetle and leaf shrinkage were observed. These were controlled

by spraying recommended doses of carbendazim and monolik pesticides.

### Irrigation Scheduling

Initially, irrigation was provided through a garden hose for 10 days for crop establishment. Afterwards irrigation was scheduled using the pan evaporation method based on 100% pan evaporation (PE). Meteorological parameters such as pan evaporation and rainfall during the experimental period were obtained from the Department of Agricultural Meteorology of the university.

Crop evapotranspiration was calculated as:

$$ET_c = K_c * K_p * CPE \quad \dots (1)$$

Where,

K<sub>c</sub> = Crop coefficient values

K<sub>p</sub> = Pan coefficient (0.7)

CPE = cumulative pan evaporation

Crop coefficient of okra crop was taken from Patil and Tiwari, 2018.

The volume of water applied was calculated by using the following formula (Kaulage, 2017):

$$V = \frac{ET_c * L_s * E_s * W_a}{EU} \quad \dots (2)$$

Where

V = volume of water per plant (L)

L<sub>s</sub> = lateral spacing

E<sub>s</sub> = emitter spacing

W<sub>a</sub> = wetted area factor (0.7)

EU = emission uniformity (90%)

Irrigation duration was determined by:

$$\text{Irrigation time (h)} = \frac{V}{q} \quad \dots (3)$$

where q represents dripper discharge (L h<sup>-1</sup>).

### Soil Moisture Measurement

Soil samples were collected using a tube auger from depths of 0–15, 15–30, 30–45 and 45–60 cm at different distances from the dripper. Soil moisture content was determined using the gravimetric method by drying samples in an oven at 105°C for 24 hours.

Soil moisture content was calculated as:

$$\begin{aligned} \text{Moisture content (percent)} \\ = \frac{W_1 - W_2}{W_2} * 100 \quad \dots (4) \end{aligned}$$

Where,

W<sub>1</sub> = weight of soil sample before drying (gm)

W<sub>2</sub> = weight of soil sample after drying (gm)

### Crop Yield:

Total yield per plot was calculated by summing the weight of fruits obtained from successive harvests.

### Efficiency Parameters

Irrigation Water Use Efficiency (IWUE) was calculated as:

$$\begin{aligned} \text{IWUE (kg m}^{-3}\text{)} \\ = \frac{\text{Weight of fruit (kg)}}{\text{Amount of water applied (m}^3\text{)}} \quad \dots (5) \end{aligned}$$

Fertilizer Use Efficiency (FUE) was determined as:

$$FUE(kg\ kg^{-1}) = \frac{Weight\ of\ fruit\ (kg)}{Amount\ of\ fertilizer\ applied\ (kg)} \dots (6)$$

**Statistical Analysis**

The experimental data were statistically analyzed using split plot design analysis with the help of OPSTAT statistical software (Sheoran, 2010). Analysis of variance (ANOVA) was performed and treatment means were compared using the critical difference (CD) at the appropriate significance level.

**RESULTS AND DISCUSSION**

**Crop yield:** Table 1 represents the effect of crop geometry (G), irrigation frequency (I), and their two-way interactions on the average total yield (q ha<sup>-1</sup>) of okra. Under normal geometry (lateral spacing 45 cm), the total yield recorded under daily irrigation was higher by 4.62, 9.69, and 14.35 percent compared with alternate day irrigation, irrigation after three days, and irrigation after five days, respectively.

**Table 1.** Effect of crop geometry (G) and irrigation frequency (I) and their two way interactions on average total yield (q ha<sup>-1</sup>) of okra

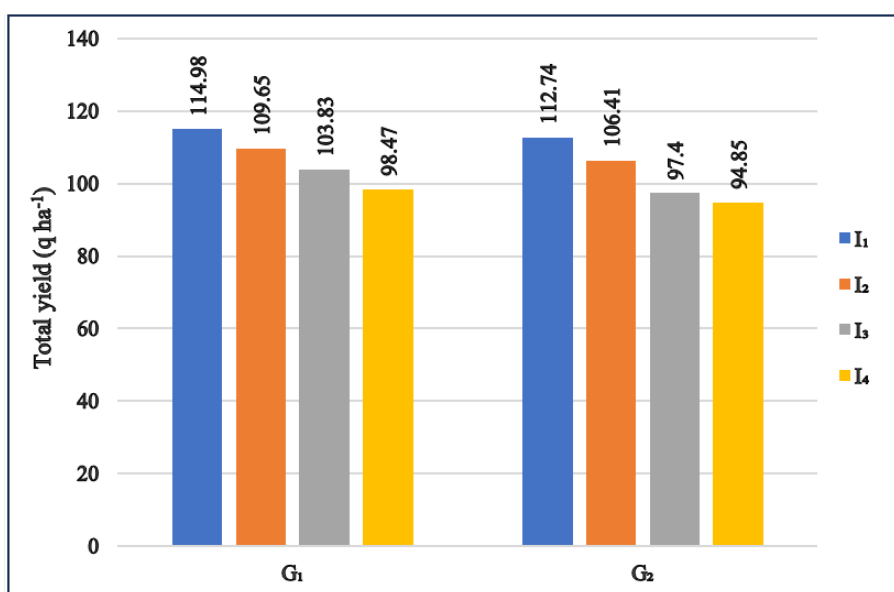
G X I Mean table						CD(p= 0.05)
G \ I	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	Mean G	
G <sub>1</sub>	114.98	109.65	103.83	98.47	106.74	G X I 2.37
G <sub>2</sub>	112.74	106.41	97.40	94.85	102.85	
Mean I	113.86	108.03	100.62	96.66		G 2.08
						I 1.27

Similar findings were reported by Haris *et al.* (2014), who observed that daily irrigation was more effective for improving okra production. In paired row geometry (lateral spacing 90 cm), the total yield under daily irrigation was higher by 5.61, 13.60, and 15.85 percent compared with alternate day irrigation, irrigation after three days, and irrigation after five days, respectively.

When comparing total yield under both crop geometries, normal geometry produced higher yields across the respective treatments. Normal geometry ensures a more uniform distribution of plants across the field, which contributes to greater cumulative

yield. Madisa *et al.* (2014) also reported that wider spacing did not significantly increase fruit yield, while Maurya *et al.* (2013) indicated that closer spacing produced higher yield compared with wider spacing.

Among all treatment combinations, the maximum total yield (114.98 q ha<sup>-1</sup>) was recorded in treatment G<sub>1</sub>I<sub>1</sub>, whereas the minimum yield (94.86 q ha<sup>-1</sup>) was observed in treatment G<sub>2</sub>I<sub>4</sub> (Figure 1). The interaction effect between crop geometry and irrigation frequency on the average total yield of okra was found to be statistically significant.



**Fig. 1:** Average total yield (q ha<sup>-1</sup>) of okra under different treatments

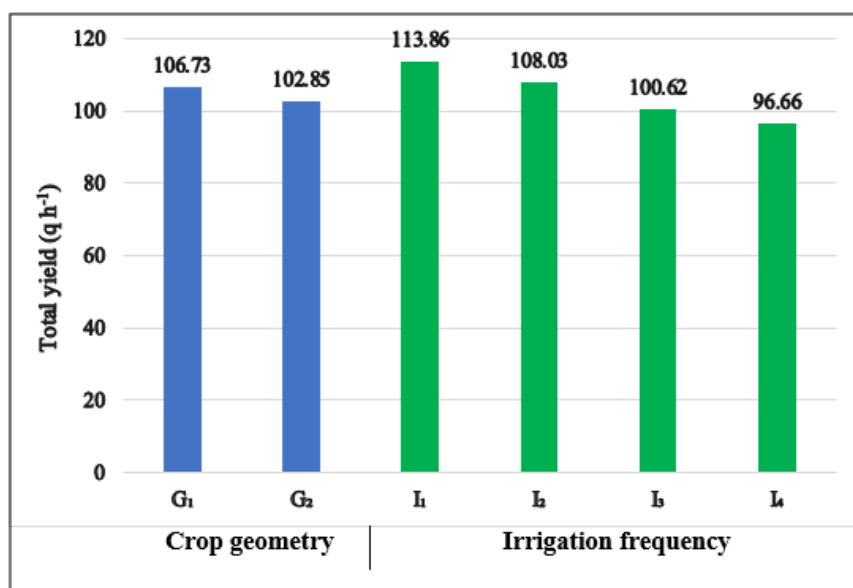


Fig. 2: Effect of crop geometry (G) and irrigation frequency (I) on average total yield (q ha<sup>-1</sup>) of okra

Okra is generally cultivated during the summer season when temperatures remain high. Under such conditions, daily irrigation maintains an adequate soil water–air balance, which promotes better plant growth and may be responsible for higher yields under this irrigation frequency. The reduced yields under alternate day irrigation and irrigation after three and five days may be attributed to mild moisture stress during critical growth stages, caused by the vertical movement of water in the sandy soil of the study area.

The effect of crop geometry on average total yield of okra was statistically significant. Treatments with normal geometry recorded a higher average yield (106.74 q ha<sup>-1</sup>) compared with paired row geometry (102.85 q ha<sup>-1</sup>) (Table 1 and Fig. 2). Similarly, irrigation frequency significantly influenced the average total yield of okra. The highest yield was obtained under daily irrigation (113.86 q ha<sup>-1</sup>), followed by alternate day irrigation (108.03 q ha<sup>-1</sup>),

irrigation after three days (100.62 q ha<sup>-1</sup>), and irrigation after five days (96.66 q ha<sup>-1</sup>) (Table 1 and Fig. 2).

**Irrigation water use efficiency**

Table 2 presents the effect of crop geometry (G), irrigation frequency (I), and their two-way interactions on irrigation water use efficiency (IWUE) of okra in terms of yield obtained per unit of water applied (kg m<sup>-3</sup>) on a hectare basis. Since an equal amount of irrigation water was applied in all treatments, variations in IWUE were primarily due to differences in total yield. Therefore, higher yields corresponded to higher IWUE values.

Under both normal and paired row geometries, daily irrigation resulted in higher IWUE compared with alternate day irrigation, irrigation after three days, and irrigation after five days. This indicates that daily irrigation provides an optimal irrigation schedule for improving water productivity.

Table 2. Effect of crop geometry (G) and irrigation frequency (I) and their two way interactions on irrigation water use efficiency of okra

G X I Mean table						CD (p= 0.05)
G \ I	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	Mean G	G X I 0.11 G 0.10 I 0.06
G <sub>1</sub>	5.68	5.42	5.13	4.87	5.27	
G <sub>2</sub>	5.57	5.25	4.81	4.68	5.08	
Mean I	5.62	5.34	4.97	4.78		

Figure 3 shows that the highest IWUE (5.68 kg m<sup>-3</sup>) was observed in treatment G<sub>1</sub>I<sub>1</sub>, whereas the lowest IWUE (4.68 kg m<sup>-3</sup>) was recorded in treatment G<sub>2</sub>I<sub>4</sub>. Similar results were reported by Jeelani *et al.* (2017). When comparing crop geometries, normal geometry

consistently produced higher IWUE than paired row geometry at the corresponding irrigation frequencies. The interaction effect of crop geometry and irrigation frequency on IWUE at 90 DAS was also found to be statistically significant.

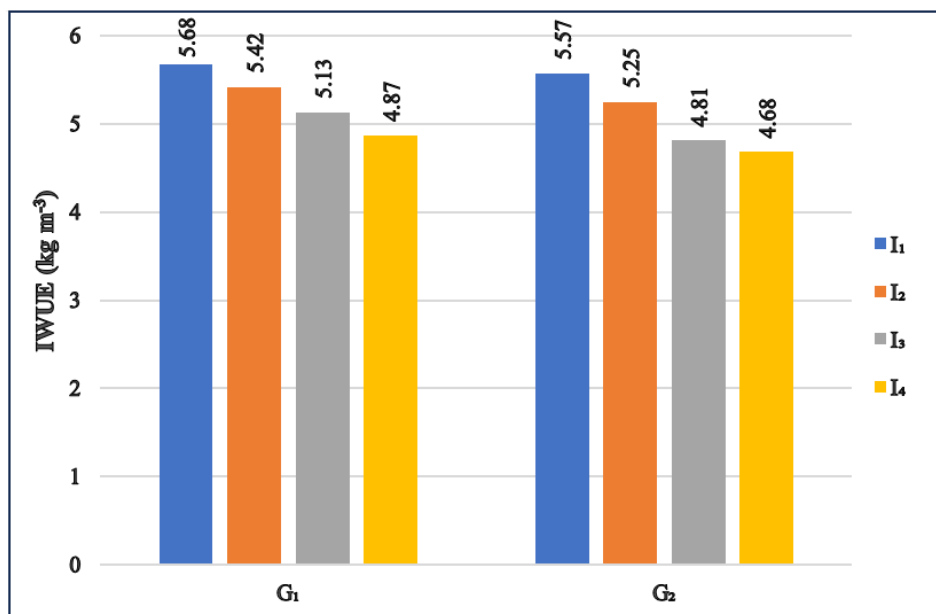


Fig. 3: Irrigation water use efficiency of okra under different treatments

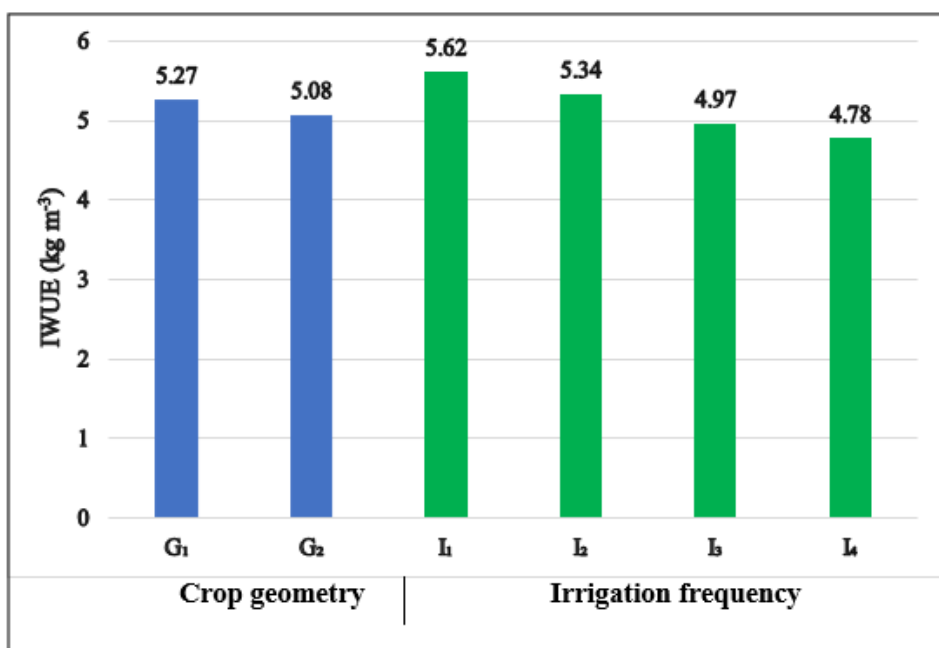


Fig. 4: Effect of crop geometry (G) and irrigation frequency (I) on irrigation water use efficiency of okra

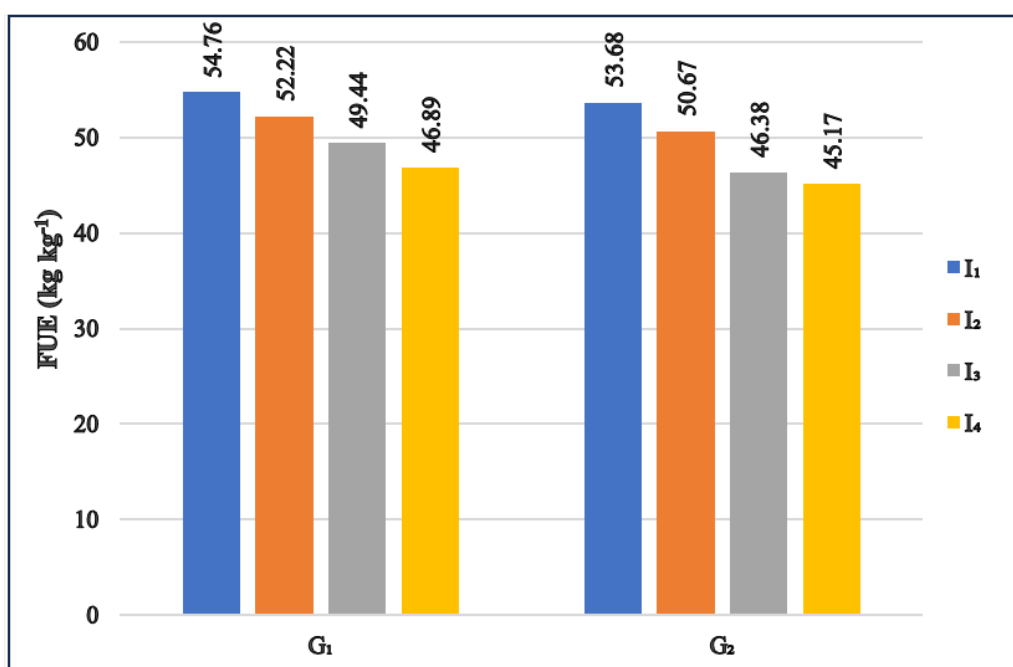
The effect of crop geometry on average IWUE was statistically significant, with normal geometry recording higher IWUE (5.27 kg m<sup>-3</sup>) compared with paired row geometry (5.08 kg m<sup>-3</sup>) (Table 2 and Fig. 4). Irrigation frequency also had a significant effect on IWUE. The highest average IWUE was obtained under daily irrigation (5.62 kg m<sup>-3</sup>), followed by alternate day irrigation (5.34 kg m<sup>-3</sup>), irrigation after three days (4.97 kg m<sup>-3</sup>), and irrigation after five days (4.78 kg m<sup>-3</sup>) (Table 2 and Fig. 4).

**Fertilizer use efficiency**

Table 3 illustrates the effect of crop geometry (G), irrigation frequency (I), and their two-way interactions on fertilizer use efficiency (FUE) of okra, expressed as yield obtained per unit quantity of fertilizer applied (kg kg<sup>-1</sup>) on a hectare basis. Since an equal amount of fertilizer was applied across all treatments, variations in FUE were mainly attributed to differences in total yield.

**Table 3.** Effect of crop geometry (G) and irrigation frequency (I) and their two way interactions on fertilizer use efficiency of okra

G X I Mean table						CD (p= 0.05)
G \ I	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	Mean G	
G <sub>1</sub>	54.76	52.22	49.44	46.89	50.83	G X I 1.13
G <sub>2</sub>	53.68	50.67	46.38	45.17	48.98	
Mean I	54.22	51.45	47.91	46.03		G 1.02
						I 0.60



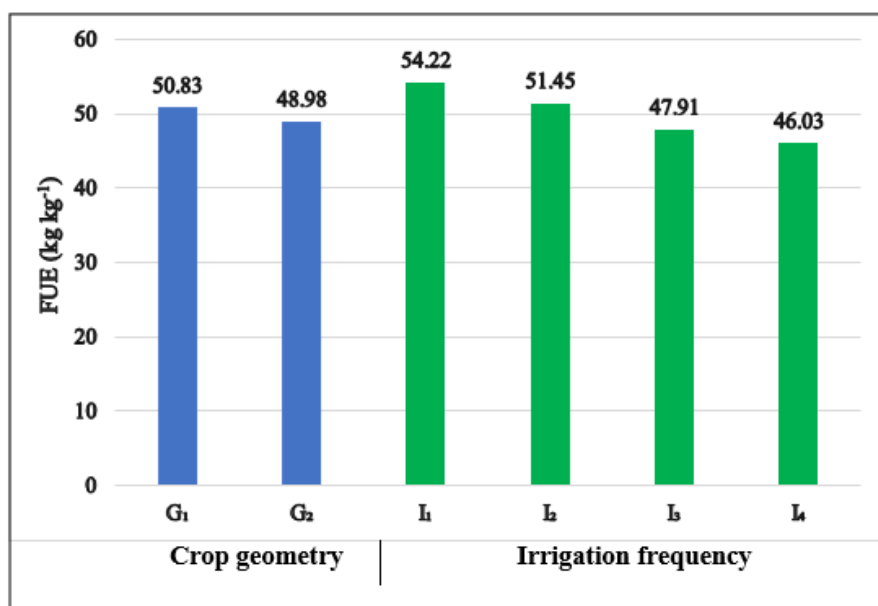
**Fig. 5:** Fertilizer use efficiency of okra under different treatments

Under both normal and paired row geometries, daily irrigation resulted in higher FUE compared with alternate day irrigation, irrigation after three days, and irrigation after five days, indicating that daily irrigation provides optimal conditions for nutrient utilization.

Figure 5 shows that the highest FUE (54.76 kg kg<sup>-1</sup>) was recorded in treatment G<sub>1</sub>I<sub>1</sub>, whereas the lowest value (45.17 kg kg<sup>-1</sup>) was observed in treatment G<sub>2</sub>I<sub>4</sub>. In comparison between crop geometries, normal geometry consistently showed higher FUE than paired row geometry at the corresponding irrigation frequencies. The interaction effect of crop

geometry and irrigation frequency on fertilizer use efficiency of okra was also statistically significant.

The effect of crop geometry on average FUE was statistically significant, with normal geometry recording higher FUE (50.83 kg kg<sup>-1</sup>) compared with paired row geometry (48.98 kg kg<sup>-1</sup>) (Table 3 and Fig. 6). Varughese *et al.* (2014) and Arunadevi *et al.* (2023) also reported that single-row drip lateral geometry achieved higher yield compared with double-row drip lateral geometry with the same fertilizer application, mainly due to differences in plant density, root competition, and nutrient uptake efficiency.



**Fig. 6:** Effect of crop geometry (G) and irrigation frequency (I) on fertilizer use efficiency of okra

Irrigation frequency also significantly affected fertilizer use efficiency. The highest average FUE was recorded under daily irrigation (54.22 kg kg<sup>-1</sup>), followed by alternate day irrigation (51.45 kg kg<sup>-1</sup>), irrigation after three days (47.91 kg kg<sup>-1</sup>), and irrigation after five days (46.03 kg kg<sup>-1</sup>) (Table 3 and Fig. 6). Higher irrigation frequency improves fertilizer use efficiency in okra by maintaining continuous nutrient availability, reducing nutrient losses, and maximizing pod yield per unit of fertilizer applied. In contrast, less frequent irrigation intervals may reduce FUE due to moisture stress periods and increased nutrient losses. Similar observations were also reported by Arunadevi *et al.* (2023).

## CONCLUSIONS

The present study demonstrated that both crop geometry and irrigation frequency significantly influenced the yield, irrigation water use efficiency (IWUE), and fertilizer use efficiency (FUE) of okra under drip irrigation. Among the irrigation treatments, daily irrigation produced the highest total yield, IWUE, and FUE, whereas irrigation after five days resulted in the lowest values of these parameters. Higher irrigation frequency maintained favorable soil moisture conditions during the crop growth period, which enhanced plant growth and ultimately increased yield and resource use efficiency.

Crop geometry also showed a significant effect on okra performance. Normal geometry with a lateral spacing of 45 cm recorded higher yield, IWUE, and FUE compared with paired row geometry with 90 cm lateral spacing. The higher productivity under normal geometry may be attributed to more uniform plant distribution and improved utilization of water and nutrients.

The interaction between crop geometry and irrigation frequency was also found to be significant. The combination of normal geometry with daily irrigation (G<sub>1</sub>I<sub>1</sub>) resulted in the maximum yield (114.98 q ha<sup>-1</sup>), IWUE (5.68 kg m<sup>-3</sup>), and FUE (54.76 kg kg<sup>-1</sup>), whereas the lowest values were recorded under paired row geometry with irrigation after five days (G<sub>2</sub>I<sub>4</sub>).

Therefore, the results indicate that maintaining normal crop geometry along with daily irrigation scheduling is the most effective strategy for improving yield and resource use efficiency of okra under drip irrigation conditions in sandy loam soils.

## REFERENCES

Adeogun, E.O. (2016). Yield response of okra to irrigation frequency and amount in a sprinkler irrigation system. *Continental Journal of Agricultural Science*, **10**(2): 24–31.

[Google Scholar](#)

Arunadevi, K., Singh, M., Khanna, M., Mishra, A.K., Prajapati, V.K., Denny, F., Ramachandran, J. and Maruthi Sankar, G.R. (2023). Soil-matric-potential-based irrigation scheduling to increase yield and water productivity of okra. *Water*, **15**(24): 4300.

[Google Scholar](#)

Choudhary, S., Chandra, A. and Yadav, P.K. (2012). Effect of crop geometry on okra (*Abelmoschus esculentus*) cultivars under different irrigation levels and mulching. *Progressive Horticulture*, **44**(2): 276–280.

[Google Scholar](#)

Gopalan, C., Rama satri, B.V. and Balasubramanian, S.C. (1996). *Nutritive Value of Indian Foods*. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India.

[Google Scholar](#)

- Haris, A.A., Kumar, S., Singh, A.K. and Rajan, K.** (2014). Drip irrigation scheduling in okra (*Abelmoschus esculentus* L. Moench). *HortFlora Research Spectrum*. Volume 3 (3): pp 274-77. [Google Scholar](#)
- Jeelani, J., Katoch, K.K. and Sandal, S.K.** (2017). Effect of drip fertigation levels on soil water dynamics, water use efficiency, yield and quality parameters of broccoli (*Brassica oleracea* L. var. *italica*) in wet temperate zone of Himachal Pradesh. *Indian Journal of Soil Conservation*, **45**(1): 96-104. [Google Scholar](#)
- Kaulage, P.P.** (2017). Studies on growth and yield of onion crop under different moisture regimes with subsurface drip irrigation. *M.Sc. Thesis*, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra, India. [Google Scholar](#)
- Kumar, N., Kumar, S., Duhan, D., Singh, A., Sidhpuria, M.S., Antil, S.K., Kumar, A. and Vikas, V.** (2023). Production of subsurface drip-irrigated okra under different lateral spacings and irrigation frequencies. *Water SA*, **49**(2): 164-178. [Google Scholar](#)
- Kumar, S., Sanjay Kumar, S.K., Sharma, S.K., Rajpaul, R. and Ram Prakash, R.P.** (2016). Effects of irrigation frequency and salinity under drip irrigation on okra (*Abelmoschus esculentus* L.). *Journal of Soil and Water Conservation*, **15** (2), 114-119. [Google Scholar](#)
- Madisa, M.E., Mathowa, T., Mpofu, C. and Oganne, T.A.** (2014). Effects of plant spacing on the growth, yield and yield components of okra (*Abelmoschus esculentus* L.) in Botswana. *American Journal of Experimental Agriculture*, **6**(1): 7-14. [Google Scholar](#)
- Maurya, R.P., Bailey, J.A. and Chandler, J.S.A.** (2013). Impact of plant spacing and picking interval on the growth, fruit quality and yield of okra (*Abelmoschus esculentus* L. Moench). *American Journal of Agriculture and Forestry*, **1**(4): 48-54. [Google Scholar](#)
- National Horticulture Board (NHB).** (2022). *Indian Horticulture Database 2021-22*. Ministry of Agriculture and Farmers Welfare, Government of India, Gurugram, Haryana. Available at: <https://nhb.gov.in> [Google Scholar](#)
- Sharma, P., Kaushal, A., Singh, A. and Garg, S.** (2016). Growth and yield attributes of okra under influence of drip irrigation. *Journal of Engineering Research and Applications*, **6**(2): 85-91. [Google Scholar](#)
- Sheoran, O.P., Tonk, D.S., Kaushik, L.S., Hasija, R.C. and Pannu, R.S.** (1998). Statistical software package for agricultural research workers (OPSTAT). CCS Haryana Agricultural University, Hisar, India. [www.hau.ac.in](http://www.hau.ac.in) [Google Scholar](#)
- Varughese, A., Menon, J.S. and Mathew, E.K.** (2014). Effect of fertigation levels and drip system layout on performance of okra under plastic mulch. *Journal of Agricultural Engineering*, **51**: 28-32. [Google Scholar](#)