www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(9): 1874-1879

www.thepharmajournal.com
Received: 27-06-2023
Accepted: 06-08-2023

**Sushama Londhe**
Department of Irrigation and Drainage Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering & Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

**Shailendra Gadge**
Department of Irrigation and Drainage Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering & Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

**Dhanashree Patil**
Junior Vegetable Breeder, AICRP VC, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

**Corresponding Author:**
**Sushama Londhe**
Department of Irrigation and Drainage Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering & Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

# Response of okra to drip irrigation regimes and mulch

**Sushama Londhe, Shailendra Gadge and Dhanashree Patil**

## Abstract
An experiment on okra crop was carried out at the Instructional Farm, Dr. A. S. College of Agricultural Engineering and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri during February, 2022 to June, 2022. The field experiment was laid out in factorial randomized block design with three replications. The main plot treatment consisted of drip irrigation @ 120 per cent ETc, 100 per cent ETc, 80 per cent ETc, 60 per cent ETc and 40 per cent ETc and sub-treatment consisted of treatments with mulch and without mulch. The total numbers of treatment were ten and replicated thrice. The study indicated that the growth parameters of okra *viz*., plant height (158.02 cm) at 90 DAS, days to 50 per cent flowering (32.33 days), root depth (47.55 cm) and the yield contributing character *viz*., fruit diameter (1.79 cm), fruit length (12.19 cm) and average fruit weight (13.28 g) were maximum for drip irrigation with 100 per cent ETc with plastic mulch. Also 100 per cent irrigation with plastic mulch gave maximum yield (17.54 q $ha^{-1}$) than other treatments. The highest water use efficiency (36.83 kg $ha^{-1}cm^{-1}$) was obtained in treatment with drip irrigation @ 60 per cent ETc with silver- black plastic mulch. The benefit cost ratio was maximum (1.79) in treatment with drip irrigation @ 100 per cent ETc with silver black plastic mulch while minimum benefit cost ratio (0.47) was observed in treatment with drip irrigation @ 40 per cent ETc. without mulch. Finally, the study revealed that the summer plantation of okra crop with drip irrigation @ 100 per cent of ETc along with silver-black plastic mulch is beneficial under semi-arid conditions of Rahuri, District Ahmednagar of Maharashtra state for economical production of summer okra under mulching practices.

**Keywords:** Drip, irrigation, mulch, fruit, yield, okra

## Introduction
Among the top sectors, agriculture fulfils the key requirements for India's development. Water is an important aspect of a sustainable agricultural system and is regarded as a necessary input for crop growth. India is blessed with abundant water resources, but the amount that can be used for irrigation is actually limited. It is beneficial to utilise water effectively and irrigate more land with the available water resources (Zaman *et al*., 2001) [4]. Therefore, to increase crop production, irrigation practices need to be improved. Drip irrigation or trickle irrigation is a type of micro-irrigation that has the potential to conserve water and nutrients. It enables water to trickle slowly to plant roots from either above or below the soil surface. Okra (*Abelmoschus esculentus* L.) is one of the species of the Malvaceae family that is widely grown and consumed.
A temperature range of 24-27 °C is ideal for its growth. Okra is an affordable source of protein, carbohydrates, vitamins, minerals, dietary fibre, and additional phytonutrients with health benefits. It is also a good source of iodine and helpful for treating goitre. In India, Okra is a prominent vegetable crop that is grown for its young, tender green fruits during the summer and rainy seasons. India is the top producer of okra in the world, ranking first (72.9%) (Anonymous 2017a) [2].
Water is needed to compensate all the water losses through evapotranspiration in a plant. The crop water requirement varies with crop growth stage. Crop water used at the different growth stages are added to determine the crop water requirement for the whole growing season.
Mulching is the practice of covering the soil to create conditions that are more favourable for plant growth, development and effective crop production. In the technical sense, mulch is the covering of soil. Particularly in tropical agro-systems, there has been an increase in interest in the use of drip irrigation systems and mulching technologies together to produce vegetables in recent years. Mulch helps to regulate soil temperature. This effect of regulating the temperature promotes plant root development and prevents soil erosion. (Elevitch *et al*. 1998) [7]. Mulching enhances nutrients and water retention in the soil, promotes favourable soil microbial activity and worms, and suppresses weed growth.

In comparison to bare soil cultivation, mulching can significantly improve plant health and lower maintenance when executed properly.

Drip irrigation technology undoubtedly plays a more significant role as a result of rising demands on scarce water resources and the need to reduce environmental consequences.

In the view of above consideration, the present study "Response of Okra to drip irrigation regimes and mulch" has been undertaken.

## Materials and Methods

### Location and layout of field plot

The field experiment was carried out at the Instructional Farm, Department of Irrigation and Drainage Engineering, Dr. ASCAE&T, Mahatma Phule Krishi Vidyapeeth, Rahuri during the period from February 2022 to June 2022. Geographically, the farm lies at 74º 19' 00'' E longitude and 19º 24' 00'' N latitude at 657 m above the mean sea level. The soil of the experiment plot was sandy clay loam, low in available nitrogen, high in organic carbon and very high in available phosphorus and potassium. The soil pH was slightly alkaline in nature.

The field experiment was laid out in factorial randomized block design with 10 treatments and three replications. The treatments were as follows:

**$T_1$:** Drip irrigation @ 120% of ETc with silver-black plastic mulch.

**$T_2$:** Drip irrigation @ 120% of ETc without mulch.

**$T_3$:** Drip irrigation @ 100% of ETc with silver-black plastic mulch.

**$T_4$:** Drip irrigation @ 100% of ETc without mulch.

**$T_5$:** Drip irrigation @ 80% of ETc with silver-black plastic mulch.

**$T_6$:** Drip irrigation @ 80% of ETc without mulch.

**$T_7$:** Drip irrigation @ 60% of ETc silver-black plastic with mulch.

**$T_8$:** Drip irrigation @ 60% of ETc without mulch.

**$T_9$:** Drip irrigation @ 40% of ETc silver-black plastic with mulch.

**$T_{10}$:** Drip irrigation @ 40% of ETc without mulch.

### Estimation of irrigation water requirement

The FAO Penman-Monteith method was used to estimate ETr. Irrigation was applied daily throughout the crop period. Water to be applied varied according to the treatments. ETc was calculated as:

$$ETc = ETr \times Kc$$

Where,

ETc = Crop evapotranspiration (mm day$^{-1}$)

ETr = Reference crop evapotranspiration (mm day$^{-1}$)

Kc = Crop coefficient

The daily crop coefficient values were estimated by adopting the four degree polynomial equation developed using FAO data on Kc values:

Kct = -7.033(t/T)4+10.83(t/T)3-3.837(t/T)2+0.454(t/T)+0.429

Where,

$Kc_t$ = Crop coefficient on t$^{th}$ day

T = Number of days since sowing

T = Total crop growth period (days)

### Time of operation

The operating time for the drip irrigation system was calculated by using following equation,

$$T = \frac{Amount\ of\ water\ to\ be\ appiled\ (lit)}{Discharge\ of\ dripper\ (\ lit\ hrs{-}1\ ) \times No.of\ drippers \times EU}$$

Where,

T = Time of operation (hrs)

### Water requirement

The net water requirement was estimated by the following equation:

IR= [$(ETc \times Irrigation\ level\ factor) - Effective\ Rainfall(mm$ day$^{-1}$) ]

WR = IR + Effective Rainfall ($mm$ day$^{-1}$)

Where,

IR = Net Irrigation requirement (mm)

WR = Water requirement of crop (mm)

ETc = Crop evapotranspiration ($mm$ day$^{-1}$)

The factor considered as 1.2, 1.0, 0.8, 0.6 and 0.4 for respective irrigation levels.

Each plot had dimensions of 2.4 m × 1.5 m. The plant to plant and row to row distances were 0.30 and 0.60 m respectively. A buffer strip of 1 m was provided between two beds to avoid lateral movement of water from one bed to another and enable easy cultural operations like seeding, spraying and harvesting etc. Figure 1 shows the Layout of the experimental plot and overall field layout is depicted by Figure 2.

For recording various biometric observations three plants were selected from an each treatment.

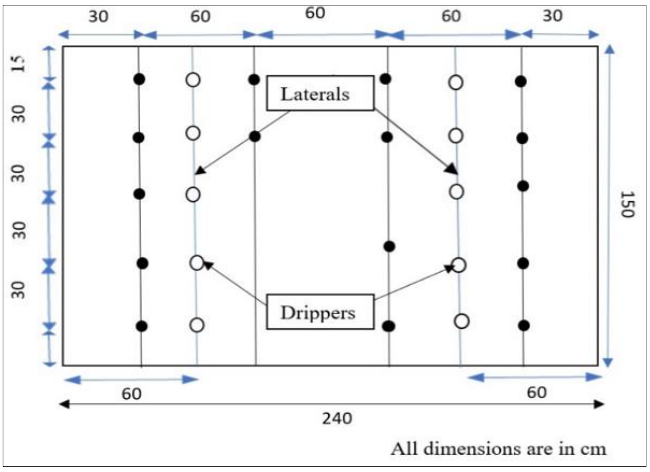


**Fig 1:** Layout of the experimental plot

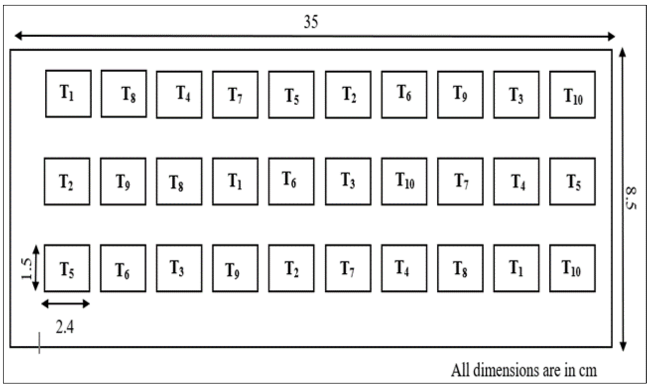


**Fig 2:** Field Layout

## Results and Discussion

### Effect of irrigation levels and mulching on plant height

The data on plant height of summer okra as influenced by irrigation levels and mulch are presented in Table 1 and depicted in Figure 3. The application of irrigation at $I_2$ was found superior at 30 DAS, 60 DAS than other treatments while treatment $I_1$ was found at par with treatment $I_2$ at 90 DAS with respect to plant height. Among the mulching treatment, the maximum value of plant height was observed in treatment $M_1$, which was superior than $M_2$ at 30, 60 and 90 DAS of okra. Compared to no-mulch, mulching increased plant height significantly. The results complied with the experiment by Adekalua *et al*. (2008) found higher plant height of okra in mulched plots due to conserving of soil water. The okra plant height was significantly influenced by interaction effect of irrigation treatments and mulching. The maximum plant height (40.65, 94.80 and158.02 cm) was observed in treatment $I_2M_1$ i.e drip irrigation with 100% ETc with silver- black plastic mulch at 30, 60 and 90 DAS. The treatment $I_1M_1$ (35.86, 87.07 and 143.05 cm) i.e. drip irrigation with 120% ETc silver-black plastic mulch was found at pat with the treatment $I_2M_1$.

**Table 1:** Effect of irrigation levels and mulching on plant height of okra

| **30 DAS** | | | | | | |
|---|---|---|---|---|---|---|
| **Irrigation Treatments Mulching** | **$I_1$** | **$I_2$** | **$I_3$** | **$I_4$** | **$I_5$** | **Mean** |
| $M_1$ | 35.86 | 40.65 | 34.52 | 31.42 | 14.91 | 31.47 |
| $M_2$ | 30.81 | 28.15 | 20.66 | 20.23 | 13.77 | 22.73 |
| Mean | 33.34 | 34.40 | 27.59 | 25.83 | 14.34 | 27.10 |
| Interaction | S.E(m) ± | | | CD at 5% | | |
| Between mulching and irrigation treatments | 1.11 | | | 3.30 | | |
| **60 DAS** | | | | | | |
| **Irrigation Treatments Mulching** | **$I_1$** | **$I_2$** | **$I_3$** | **$I_4$** | **$I_5$** | **Mean** |
| $M_1$ | 87.07 | 94.80 | 72.38 | 65.28 | 34.79 | 70.26 |
| $M_2$ | 62.79 | 59.75 | 51.10 | 41.23 | 25.96 | 48.17 |
| Mean | 73.43 | 77.28 | 61.74 | 53.25 | 30.38 | 59.21 |
| Interaction | S.E(m) ± | | | CD at 5% | | |
| Between mulching and irrigation treatments | 3.19 | | | 9.5 | | |
| **90 DAS** | | | | | | |
| **Irrigation Treatments Mulching** | **$I_1$** | **$I_2$** | **$I_3$** | **$I_4$** | **$I_5$** | **Mean** |
| $M_1$ | 143.05 | 158.02 | 135.02 | 134.62 | 109.48 | 136.12 |
| $M_2$ | 134.02 | 124.00 | 135.02 | 120.17 | 102.38 | 123.12 |
| Mean | 138.54 | 141.22 | 135.02 | 127.39 | 105.93 | 129.62 |
| Interaction | S.E(m) ± | | | CD at 5% | | |
| Between mulching and irrigation treatments | 4.55 | | | 13.52 | | |

### Effect of irrigation levels and mulching on days to 50 per cent flowering

The application of irrigation at $I_2$ (33.33) exhibited early flowering and followed by treatment $I_1$ and $I_3$. While significantly higher number of days for 50 per cent flowering were recorded for treatment $I_5$ (38.83) recorded. Among the mulching treatment, the minimum value of days required to 50 per cent flowering was observed in treatment $M_1$ (34.47) while maximum days were observed in $M_2$ (36.87) as shown in Table 2. The interaction effect of irrigation treatments and mulching had a non-significant influence on the number of days taken for 50 percent flowering of okra crop.

**Table 2:** Effect of irrigation levels and mulching on okra crop parameters

| **Treatment** | **Days to 50% flowering** | **Root Depth (cm)** | **Fruit length (cm)** | **Fruit diameter (cm)** | **Fruit weight (gm)** | **Average Yield (q per ha)** |
|---|---|---|---|---|---|---|
| **A. Main plot treatment** | | | | | | |
| I1: Drip Irrigation @120% ETc | 33.83 | 35.54 | 11.71 | 1.66 | 12.81 | 13.31 |
| I2: Drip Irrigation @100% ETc | 33.33 | 37.04 | 11.88 | 1.71 | 12.94 | 14.92 |
| I3: Drip Irrigation @80% ETc | 35.17 | 28.60 | 11.32 | 1.64 | 12.30 | 11.41 |
| I4: Drip Irrigation @60% ETc | 37.17 | 27.25 | 11.17 | 1.58 | 11.92 | 9.88 |
| I5: Drip Irrigation @40% ETc | 38.83 | 21.41 | 10.34 | 1.42 | 10.35 | 4.90 |
| S.E(m)± | 0.36 | 0.41 | 0.16 | 0.02 | 0.12 | 0.14 |
| CD at 5% | 1.08 | 1.23 | NS | 0.06 | 0.37 | 0.42 |
| **B. Sub plot treatment** | | | | | | |
| M1: With Mulch | 34.47 | 35.06 | 11.64 | 1.72 | 12.60 | 13.37 |
| M2: Without Mulch | 36.87 | 24.88 | 10.93 | 1.49 | 11.53 | 8.40 |
| S.E(m)± | 0.56 | 0.64 | 0.25 | 0.03 | 0.19 | 0.22 |
| CD at 5% | 1.67 | 1.91 | NS | 0.09 | 0.57 | 0.65 |
| Interaction | NS | 4.27 | NS | NS | NS | 1.45 |
| General Mean | 35.67 | 29.97 | 11.29 | 1.60 | 12.06 | 10.88 |

**Effect of irrigation levels and mulching on root depth**

Irrigation treatment $I_2$ (37.04 cm) recorded significantly maximum value of root depth during different growth stages of okra which was found superior than other treatments. Among the mulching treatment, treatment $M_1$ (35.06 cm) recoded significantly maximum value of root depth followed by treatment $M_2$ (24.88 cm) as shown in Table 2.This observation concurs with research by Zaman and Mallick (1991) [4] who reported that beneficial impact of mulch covers on reducing water stress is likely due to their minimization of water loss from the soil surface and regulation of soil temperature in the root zone, resulting in maximum root growth. The interaction effect of irrigation treatments and mulching had a significant influence on root depth of okra as presented in Table 3. The maximum root depth (47.55 cm) was observed in treatment $I_2M_1$ i.e. drip irrigation with 100% ETc with silver- black plastic mulch followed by other treatments.

**Table 3:** Interaction effect of different irrigation treatments and mulching on root depth of okra

| Irrigation Treatments Mulching | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ | Mean |
|---|---|---|---|---|---|---|
| $M_1$ | 43.28 | 47.55 | 31.71 | 29.97 | 22.77 | 35.06 |
| $M_2$ | 27.80 | 26.52 | 25.50 | 24.52 | 20.05 | 24.88 |
| Mean | 35.54 | 37.04 | 28.60 | 27.25 | 21.41 | 29.97 |
| Interaction | SE (m) ± | | | CD at 5% | | |
| Between mulching and irrigation treatments | 1.44 | | | 4.27 | | |

**Table 4:** Interaction effect of different irrigation treatments and mulching on average yield of okra

| Irrigation Treatments Mulching | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ | Mean |
|---|---|---|---|---|---|---|
| $M_1$ | 16.66 | 17.54 | 14.49 | 11.79 | 6.34 | 13.37 |
| $M_2$ | 9.97 | 12.29 | 8.34 | 7.96 | 3.46 | 8.40 |
| Mean | 13.31 | 14.92 | 11.41 | 9.87 | 4.90 | 10.89 |
| Interaction | SE (m) ± | | | CD at 5% | | |
| Between mulching and irrigation treatments | 0.49 | | | 1.46 | | |

**Table 5:** Interaction effect of different irrigation treatments and mulching on water use efficiency of okra

| Irrigation Treatments Mulching | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $I_5$ | Mean |
|---|---|---|---|---|---|---|
| $M_1$ | 27.31 | 28.74 | 34.70 | 36.83 | 29.74 | 31.46 |
| $M_2$ | 15.57 | 23.03 | 19.54 | 24.87 | 16.20 | 19.84 |
| Mean | 21.44 | 25.88 | 27.12 | 30.85 | 22.97 | 25.65 |
| Interaction | SE (m) ± | | | CD at 5% | | |
| Between mulching and irrigation treatments | 1.69 | | | NS | | |

**Effect of irrigation levels and mulching on fruit Length**

The significantly highest fruit length was recorded in irrigation treatment $I_2$ (11.88 cm) followed by treatment $I_1$, $I_3$ and $I_4$. Among the mulching treatment $M_1$ (11.64 cm) recorded maximum fruit length followed by treatment $M_2$ (10.93 cm) of okra crop as shown in Table 2. The fruit length was non-significantly influenced by interaction effect of irrigation treatments and mulching.

**Effect of irrigation levels and mulching on fruit diameter**

The fruit diameter was recorded significantly maximum under the treatment $I_2$ (1.71 cm) which was at par with treatment $I_1$ (1.66 cm) followed by treatments $I_3$ (1.64 cm) and $I_4$ (1.58 cm). Among the mulching, significantly maximum fruit diameter was observed in treatment $M_1$ (1.72 cm) which was superior than $M_2$ (1.49 cm) of okra crop as shown in Table 2. The maximum fruit diameter under mulch might be due maintaining moisture levels in the crop root zone, which increases water and nutrient availability to the plant. The fruit diameter of okra was non- significant influenced by interaction effect of irrigation treatments and mulching.

**Effect of irrigation levels and mulching on fruit weight**

The application of irrigation at $I_2$ (12.94 grams) which was at par with the treatment $I_1$ (12.81 grams) and followed by treatment $I_3$ and $I_4$ (12.30 and 11.92 grams). Significantly highest fruit weight was recorded in treatment $M_1$ (12.60 grams) which was superior than $M_2$ (11.53 grams) of okra crop as shown in Table 2. Mulching protected the plant from soil moisture stress as well as other physico-chemical competitors in the soil and aided in maintaining a good internal water balance in the plant body complied with the experiment by Bogle *et al.* (1989) [5]. The fruit weight was non-significantly influenced by interaction effect of irrigation treatments and mulching.

**Effect of irrigation levels and mulching on average Yield**

Significantly maximum yield of okra per hectare was observed in treatment $I_2$ (14.92 q $ha^{-1}$) which was was superior than other treatments. Treatment $I_2$ was followed by treatment $I_1$ (13.31 q $ha^{-1}$), $I_3$ (11.41 q $ha^{-1}$) and $I_4$ (9.88 q $ha^{-1}$). It might be because the soil moisture level was maintained close to the field capacity throughout the crop growth period. Beyond a certain point, adding more water will reduce the yield. The increased yield in $I_2$ than $I_1$ might be due to this reason. Among mulching the maximum yield of okra per hectare was observed in treatment $M_1$ (13.37 q $ha^{-1}$) which was superior than $M_2$ (8.40 q $ha^{-1}$) as shown in Table 2.

The yield of okra was significantly influenced by interaction effect of irrigation treatments and

Mulching as depicted in figure 4. Similar results were found by Singh *et al.* (2009) [11] and Zhang *et al.* (2017) [15]. Table 4 reveals that maximum yield (17.54 q $ha^{-1}$) was observed in treatment $I_2M_1$ i.e drip irrigation with 100% ETc with silver-black plastic mulch followed by other treatments. Treatment $I_1M_1$(16.66 q $ha^{-1}$) i.e drip irrigation with 120% ETc with silver- black plastic mulch was found at par with treatment $I_2M_1$.

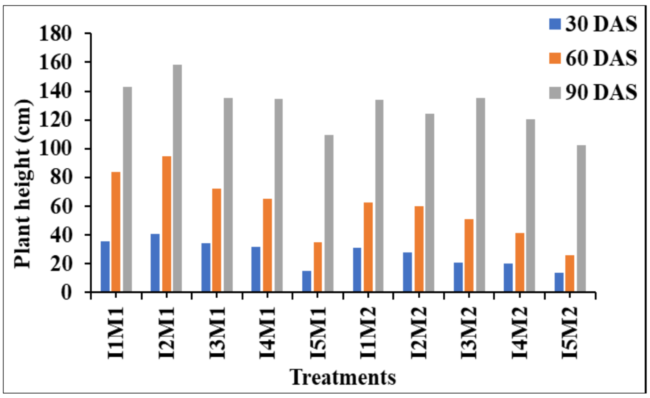


**Fig 3:** Interaction effect of irrigation levels and mulching on plant height of okra

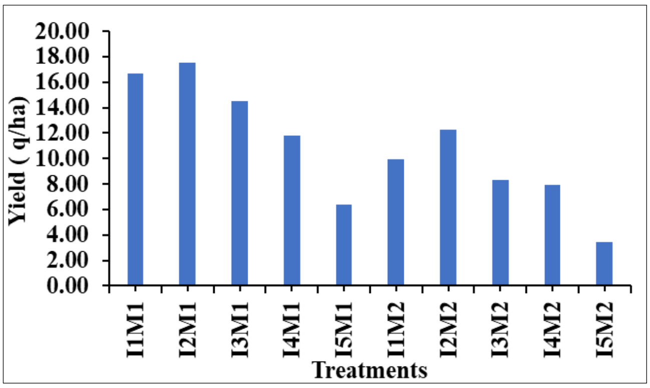


**Fig 4:** Interaction effect of irrigation levels and mulching on average yield of okra

### Effect of irrigation levels and mulching on water use efficiency

The highest water use efficiency (36.83 kg $ha^{-1}cm^{-1}$) was obtained in treatment $I_4M_1$ (i.e. 60% ETc x silver black plastic mulch). The lowest water use efficiency (16.20 kg $ha^{-1}cm^{-1}$) was obtained in treatment $I_5M_2$ (i.e. 40% ETc x No mulch) as presented in Table 5.

### Crop Water Production Function for Okra Crop Under Different Irrigation Treatments

The relationship between yield obtained and the total amount of water used by the crop based on evapotranspiration is known as the crop water production function. The water production function of 3rd order was observed for okra crop. The developed relationship is shown in Figure 5.

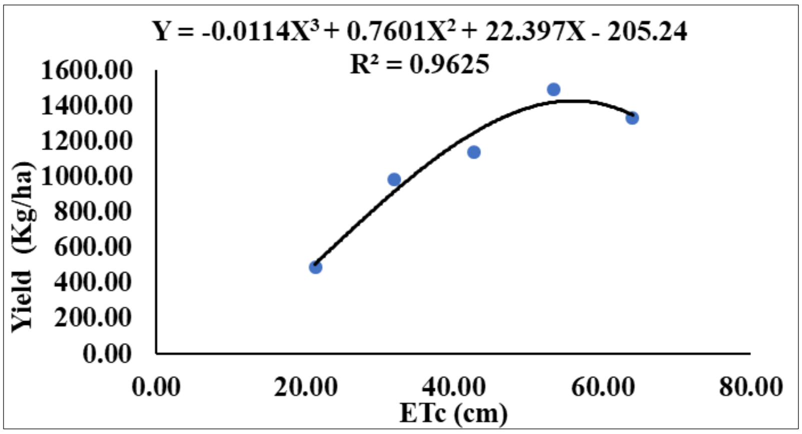


**Fig 5:** Crop water production function for okra crop under different irrigation treatments

### Crop yield response factor (Ky)

The ratio of relative yield reduction to relative evapotranspiration deficit is known as the yield response factor (Ky). The value of Ky is 0.83. The linear regression equation was developed between relative evapotranspiration deficit and relative yield deficit as shown in Figure 6. Generally, higher value indicate that the crop will have a greater yield loss when the crop water requirement are not met. Therefore, Ky plays an important role in water management of okra.

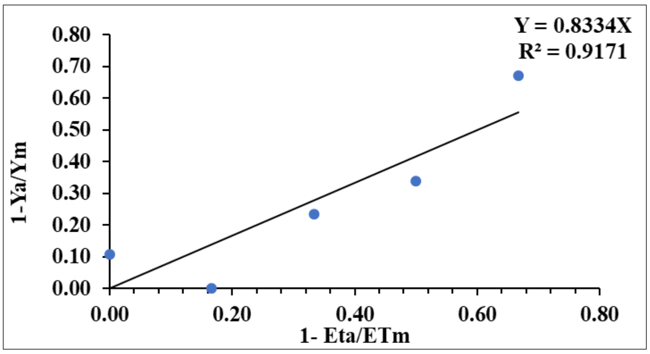


**Fig 6:** A linear regression equation between reduction in relative okra yield to reduction in relative evapotranspiration

### Cost Economics

The benefit cost ratio was maximum in treatment $I_2M_1$ (i.e.100% ETc x silver-black plastic mulch) as 1.79 followed by treatment combination $I_1M_1$ as 1.69 whereas minimum benefit cost ratio was obtained in $I_2M_5$ (i.e. 40% ETc x Non-mulch) as 0.47.

### Conclusions

The study concluded that with rising demands on scarce water resources and the need to reduce environmental consequences, drip irrigation technology along with mulching is recommended for summer plantation of okra crop for higher yield and better benefit cost ratio under semi-arid conditions of Rahuri, District Ahmednagar of Maharashtra state. The results of experiment revealed that the summer plantation of okra crop with drip irrigation @ 100 per cent ETc with silver-black plastic resulted in higher yield as compared to other treatments.

### References

1. Adekalua KO, Ogunjimia LA, Olaosebikanb FO, Afolayanb SO. Response of Okra to Irrigation and Mulching. International Journal of Vegetable Science. 2008;14(4):339-350.
2. Anonymous. Horticulture statistics at glance (2017). Published by Department of Agriculture, Cooperation and Farmers Walfare, Ministry of Agriculture and Farmers Walfare, Govt. of India; c2017a. p. 458.
3. Anonymous. Horticulture statistics at glance (2017). Published by Department of Walfare, Govt. of India. 2017b;141:511.
4. Biswas SK, Akanda AR, Rahman MS, Hossain MA. Effect of drip irrigation and mulching on yield, water-use efficiency and economics of tomato. Plant Soil Environment. 2015;61(3):97-102.
5. Bogle CR, Hartz TK, Nunez C. Comparison of subsurface trickle and furrow irrigation on plastic mulch and bare soil for tomato production. Journal of American Society for Horticultural Sciences. 1989;114:40-43.

6. Chandra R, Singh PK. Response of okra to drip irrigation and mulching in Tarai condition of Uttarakhand. International Journal of Agriculture Sciences. 2019;11(15):8854-8857.
7. Elevitch CR, Wikinson KM. Greater plant and soil health for less work. Permanent Agriculture Resources, Holualo; c1998.
8. Ganesh RB, Rao IB, Raja Kumar KN. Response of okra to different levels of drip irrigation on growth, yield and water use efficiency. International Journal of Agricultural Engineering. 2015;8(1):47-53.
9. Rao PS, Lakhawat SS. Economic feasibility of okra and tomato crop grown on silver coloured poly - mulch in udaipur district of Rajasthan- A case study. The Journal of Rural and Agricultural Research. 2016;16(1):1-5.
10. Sharma P, Kaushal A, Singh A, Garg S. Growth and Yield attributes of Okra under Influence of Drip Irrigation. Journal of Engineering Research and Applications. 2016;6(2):85-91.
11. Singh R, Kumar S, Nangare DD, Meena MS. Drip irrigation and black polyethylene mulch influence on growth, yield and water-use efficiency of tomato. African Journal of Agricultural Research. 2009;4(12):1427-1430.
12. Sreeja K, Satasiya RM. Field and economics of summer okra (*Abelmoschus esculentus* L. moench.) under plastic mulching and drip irrigation. International Journal of Advances in Agricultural Science and Technology. 2020;7(3):42-49.
13. Tiwari KN, Mal PK, Singh RM, Chattopadhyay A. Response of okra (*Abelmoschus esculentus* (L.) Moench.) to drip irrigation under mulch and non-mulch conditions. Agricultural Water Management. 1998;38(2):91-102.
14. Zaman A, Mallick S. Water use and seed yield of horse gram under different moisture regimes and mulches in semi-arid region of Eastern India. Crop Science. 1991;167:39-42.
15. Zhang H, Xiong Y, Huang G, Xu X, Huang Q. Effects of water stress on processing tomatoes yield, quality and water use efficiency with plastic mulched drip irrigation in sandy soil of the Hetao Irrigation District. Agricultural Water Management. 2017;179:205-214.