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Effect of different level of drip irrigation on growth, yield and water use efficiency of okra (*Abelmoschus esculentus* L.)

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■ **ABSTRACT :** A field experiment was conducted at Zonal Research Station, Darisai, East Singhbhum, Jharkhand during 2016-2017 to estimate the water requirement for increasing the productivity of okra. The experiments were laid out in Randomized Block Design with five treatments which included four level of drip irrigation *viz.*, 100, 80, 60 and 40 per cent evapotranspiration (ET) and surface irrigation at 1.0 IW/CPE and were replicated thrice. The results revealed that higher yields (160.52 q ha^{-1}) was recorded in treatment T_1- Drip irrigation at 100 per cent ET with maximum plant height (102.6 cm) and number of branches $plant^{-1}$ (2.08) and was significantly superior over rest treatment. The water use efficiency of 58.34 kg/ha/mm was recorded in drip irrigation at 40 per cent ET. The maximum benefit-cost ratio (1.40) was noted in T_1- Drip irrigation at 100 per cent ET and minimum (0.61) in T_4 - Drip irrigation at 40 per cent ET.

■ **KEY WORDS :** Okra, Drip irrigation, Surface irrigation, Water requirement, Water use efficiency, Economics

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Okra (*Abelmoschus esculentus* L.) is one of the most important vegetable crop grown throughout the tropical and subtropical parts of the world. It is popularly known as lady finger or Bhindi. Its adaptability to a wide range of soil and climatic conditions, comparably easy agronomy makes it feasible for its round the year cultivation. In India, okra occupies about 511 thousand hectare areas under cultivation with total production of 5848.6 thousand MT and productivity of 11.44 (MT/ha). The share of India being 67.1 per cent in area of okra in the world, followed by Nigeria at 15.4 per cent and Sudan at 9.3 per cent (Varmudy, 2011). Okra is an important vegetable crop grown in Jharkhand, covering an area of 32.87 thousand hectare with production and productivity of 452.12 thousand MT and 13.75 MT/ha, respectively (Anonymous, 2017).

In the changing global scenario, nutritional security is an important issue. Vegetables are grown in 6.24 million hectare area with annual production of 98.50 million tonnes in India (Anonymous, 2006). However, this amount of production is not sufficient to meet the requirement of ever increasing population of our country. As per recommendation of World Health Organization the requirement of per capita per day of vegetables is 285 g. Contrary to this, the availability is only 145 g per capita per day. Therefore, it is necessary to indentify our efforts to increase the vegetable production in order to meet minimum requirements as well as ensuring the nutritional security of the fast growing population of the country.

Okra fruits contains fairly good amount of vitamins, minerals, proteins and carbohydrates. The nutritional value of 100 g of edible portion of okra contains 1.9 g of protein, 0.2 g fat, 6.4 g carbohydrate, 0.7 g minerals and 1.2 g fibre (Gopalan *et al.*, 1989). It has average nutritive value of 3.21, which is higher than tomato, brinjal and most of the cucurbits except bitter gourd (Grubben, 1977). Okra has a vast potential as one of the foreign exchange earner crop as it contributes about 60 per cent share of fresh vegetables export of green vegetables in India, excluding onion.

Water is one of the most important inputs essential for the production of crops. India is blessed with abundant water resources, however, due to various physiographic constraints, existing legal constraints and the present method of utilization, the utilizable water for irrigation is very limited. The misuse of water leads to water logging and salt problems.

In the present day context, improvements in irrigation practices are needed to increase crop production and to sustain the productivity level. Flood irrigation is the conventional method widely used to irrigate most of the vegetable crops grown in India. It is understood that conventional surface irrigation methods supply water unevenly with respect to space and time. In addition, losses such as evaporation, percolation, conveyance and seepage are major constraints in obtaining higher water use efficiency. So it is important to judiciously use the already existing water resources by using suitable irrigation technology that not only increases vegetable production per unit area but also per unit of water used.

Drip irrigation technology has been recognized as an answer to meet the increasing demands of water for irrigation especially for horticultural crops. Apart from water saving, enhance water use efficiency and increased yield, drip system permits the use of fertilizers, pesticides and other soluble chemicals along with the irrigation water. The overall efficiency of drip irrigation system is about 80-95 per cent as compared to that of 30-40 per cent in case of surface irrigation systems.

■ METHODOLOGY

A field experiment was conducted during *Rabi* season of 2016-2017 at Zonal Research Station, Darisai, East Singhbhum. The field is located at 23°36' North latitude, 86°54' East longitude with an altitude of 124 m above mean sea level. The mean annual rainfall is 1200 mm and mean temperature is 28°C. Soil of the experiment plot was sandy loam in texture having pH-5.81, organ carbon - 0.48 available N, P, K 247.9, 51.55 and 144.0 kg ha^{-1}, respectively. Bulk density was 1.7 g/cm^3. Soil moisture at field capacity and wilting point were 17.79 per cent and 8.0 per cent, respectively. Fertilizer dose of N, P_2O_5 and K_2O was applied at the rate of 100, 50, 50 kgha^{-1}, respectively. The following five treatments were applied in a Randomized Black Design and replicated four times T_1-Drip irrigation 100 per cent evapo-transpiration (ET) based on pan evaporation, T_2-drip irrigation at 80 per cent ET, T_3-drip irrigation at 60 per cent ET, T_4- drip irrigation at 40 per cent ET and T_5- surface irrigation based on IW/CPE ratio at 1.0 with 50 mm depth of irrigation water (IW). The daily pan evaporation was recorded from the class A type USWE pan evaporimeter, which was installed in the meteorological observatory of the station.

Pan evaporation method as suggested by (Mane *et al.*, 2006) was used for estimating volume of water for 100 per cent ET and then the 80 per cent, 60 per cent and 40 per cent ET values were obtained.

$$V = \frac{CA \times PE \times Pc \times Kc \times WA}{Eu}$$

where,

V = Volume of water required for 100 per cent ET (l/day/plant),

CA = Crop area (m),

PE = Maximum pan evaporation (mm/day),

P = Pan co-efficient,

K = Crop co-efficient,

WA = Wetted area

E = Emission uniformity in decimal.

The pan co-efficient value was 0.75 as suggested for USDA class A pan and the crop co-efficient for various growth stages was taken from Allen *et al.* (1998). The emission uniformity was evaluated by the equation as suggested by Keller and Karmeli (1974).

$$EUf = \frac{qn}{qa} x100$$

where,

EU = Field emission uniformity (%),

q = The avg. of lowest 1/4 of the emitter flow rate (l/h) and

q = The average of all emitters flow rate (l/h).

The okra seeds of variety Sonal (Hybrid okra seeds) were sown on 4th February 2016. The sowing was done by maintaining plant spacing to 50 cm x 50 cm (R x P) at a depth of 3 cm. The inline laterals were laid in between the two rows of crop having emitters with discharge rate of 2.40 lph and 40 cm apart from each other (one emitter for two plants). One common irrigation was applied first as pre-transplanting irrigation for the purpose of proper establishment of crop in all the treatments. For drip irrigation treatments, the irrigation was scheduled daily and the required quantity of water to be applied was computed every day as explained in the previous section. For surface irrigation it was scheduled at 1.0 IW/CPE ratio with 50 mm depth. The daily pan evaporation from USWB Class A pan evaporimeter was summed up and when Cumulative pan evaporation (CPE) attained the value of 50 mm, the water was carried out to the plots through the PVC pipe.

Observations on water requirement, growth character and yield of okra were recorded and analysed statistically using the analysis of variance procedure, appropriate for the Randomized Block Design. The test of significance was carried out at 5 per cent level. The water use efficiency was computed by dividing okra yield with total water applied. For economic analysis, total seasonal cost was worked as: depreciation, interest, repairs and maintenance cost of drip irrigation set + cost of cultivation + variable cost. The income from produce for different treatments was calculated taking into account the wholesale market prices of okra. The net returns were calculated considering income from produce and total seasonal cost of production. The benefit cost ratio (B:C) was estimated dividing income obtained from produce by total cost of production for each treatment.

■ RESULTS AND DISCUSSION

The emission uniformity (Eu) of drip irrigation system was found to be 90 per cent during the experimentation. The high values of emission uniformity indicated that the drip systems are operated excellently and supplying water uniformly throughout the lateral lines during the period of experiment. Edossa and Emana (2011) also found the average emission uniformity (EU) of drip system to be 89 per cent.

Growth and yield attributes:

The adoption of drip irrigation system has revealed the efficiency of the system in reducing the water requirement with increased yields and better quality in vegetable crops. Results revealed that drip irrigation levels had a significant effect on growth and yield attributing characteristics of okra (Table 1). Among Treatments, T_1 (drip irrigation at 100% ET) was found superior over other treatments in terms of maximum plant height (102.60 cm), Number of branches (2.08), fruit yield per plant (0.321 kg) and fruit yield (160.52 q/ha), whereas T_5 (surface irrigation) produced minimum values for all these characteristics with fruit yield of 105.30 q/ha. The highest yield with 100 per cent CWR was also reported by Babu *et al*. (2015) in okra, Panigrahi *et al*. (2010) in tomato and Tiwari *et al*. (2003) in cabbage. Increased yield under drip irrigation at 100 per cent ET may be attributed to optimum availability of soil moisture around the crop root zone and to better uptake and utilization by plants.

Water use efficiency (WUE):

The influence of treatments on WUE is presented in Table 1. The maximum WUE of 58.34 kg/ha/mm was recorded with treatment of drip irrigation at 40 per cent ET. The maximum WUE in T_4 might be due to lesser water use compared to other treatments. Similar finding have been reported by Tiwari *et al*. (1998) for okra and

Table 1 : Plant height, number of branches per plant, fruit yield per plant and fruit yield per hectare, water applied, water use efficiency, water saving, net income and B : C ratio of okra under different treatments

Treatments	Plant height (cm)	No. of branches per plant	Fruit yield (kg plant^{-1})	Fruit yield (q ha^{-1})	Total water applied (mm)	Water use efficiency (kg/ha/ mm)	Percentage of water saving over surface irrigation	Net Income (Rs.)	B:C ratio
T_1 - Drip irrigation at 100% ET	102.6	2.08	0.321	160.52	398.08	40.32	18.99	93755.65	1.40
T_2 - Drip irrigation at 80% ET	93.2	1.85	0.282	140.77	326.75	43.08	33.51	74005.65	1.11
T_3 - Drip irrigation at 60% ET	82.5	1.60	0.264	132.14	255.41	51.74	48.03	65375.65	0.98
T_4 - Drip irrigation at 40% ET	78.15	1.40	0.215	107.39	184.08	58.34	62.54	40625.65	0.61
T_5 - Surface irrigation	71.35	0.90	0.211	105.30	491.42	21.43	-	42054.89	0.66
C.D. (P=0.05)	8.20	0.16	0.029	14.41	-	-	-		-

Gupta *et al*. (2010) for capsicum.

Amount of water saving:

The result pertaining to water applied and water saving under different treatment are presented in Table 1. Drip irrigation with 100 per cent, 80 per cent, 60 per cent and 40 per cent ET consumed 356.66, 285.33, 213.99 and 142.66 mm water throughout the cropping season while the surface irrigated plots consumed 450.00 mm water and thereby saving irrigation water to the tune of 18.99 per cent, 33.51 per cent, 48.03 per cent and 62.54 per cent, respectively over surface irrigation. This clearly informs the potentiality of drip irrigation in saving of water over surface irrigation. This was due to lesser amount of water application through drip irrigation than surface irrigation. This fact is in agreement with the earlier finding of Babu *et al*. (2015) in okra.

Economics:

The net income and benefit cost ratio of okra as affected by different treatments are presented in Table 1. Drip irrigation at 100 per cent ET registered higher net income (Rs. 93755.65) and B:C ratio (1.40) whereas the lowest net income (Rs. 42054.89) and B:C ratio (0.69) was recorded in surface irrigation. The results obtained are in agreement with Manjunatha *et al*. (2001) and Himanshu *et al.* (2012) in cabbage and Vijayakumar *et al.* (2010) in brinjal.

Conclusion:

In okra, higher yields (160.52 q ha^{-1}) was recorded in treatment T_1 (drip irrigation at 100% ET) with maximum plant height (102.6 cm) and number of branches (2.08). The highest WUE of 58.34 kg ha^{-1} mm^{-1} was recorded in T_4. (drip irrigation at 40% ET) The maximum water saving of 62.54 per cent was observed in case of drip irrigation at 40 per cent ET. The maximum B: C ratio (1.40) was noted in T_1 (drip irrigation at 100% ET) and lowest (0.61) in T_4 (drip irrigation at 40% ET). Thus, it can be concluded that for okra crop irrigating with drip irrigation at 100 per cent ET may be recommended for getting higher yield of okra.

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