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Response of Different Irrigation and FertigationLevels on Growth and Yield of Okra (*Abelmoschusesculentus* L. Moench)

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ABSTRACT: *The field investigation was carried out to compare the growth and yield attributing characteristics of okra under different drip irrigation schedules based on pan evaporation (40, 60 and 80% of PE) and levels of fertigation viz. 50, 75, 100 per cent recommended dose of fertilizers (NPK) through drip. The growth and yield characteristics of okra were periodically monitored and recorded during the crop growth period. A control treatment of conventional application of water and fertilizer (furrow irrigation at 1.0 IW/CPE with 60 mm depth and 100% RDF) was used for comparison. For comparison among drip irrigation treatments the two factor split plot design with irrigation schedule as main and fertigation levels as sub was used for data analysis. Whereas for comparison with control the data was analyzed in randomized block design with ten individual treatments. The maximum plant height and number of leaves were obtained in I_3F_2 (0.8 CPE mm depth and 75% RDF) which was 31.0, 47.8, 84.8 cm and 12.3, 27, 38respectively 30, 60 and 90 days after sowing and found to be significantly superior over all other treatments. Among the treatments I_3F_2 (0.8 PE and 75% RDF) showed significantly highest fruit yields of 14.87 t/ha, I_1F_3 showed highest 15.62 fruits per plant and I_1F_2 showed highest 14.55 g average weight of fruit. Perimeter and length of fruit were highest in $I_3F_2$and I_1F_2 i.e. 6.64 and 14.25 respectively.*

Keywords: *Drip Irrigation,Fertigation, IW/CPE,Okra,Growth Parameters, Crop yield.*

INTRODUCTION

"Okra" *(AbelmoschusesculentusL.)* is an herbaceous annual plant commonly known as 'Bhendi' or 'Ladies finger' belong to a family 'Malvaceae'. Okra is a native of Africa. It is grown throughout tropical and subtropical regions and also in the warmer part of the temperate region. Okra is grown throughout the world as an important vegetable crop covering an area of 6395 kg/ha. India is the second largest producer of vegetables ne×t to china with 2.8% (6.2 Mha) of total cropped area under vegetables having annual production of 71.66 million tonnes. Amongst all vegetables cultivated in India, Okra is one of the most popular vegetable. In india okra occupies an area of about 3,70,000 ha with the productivity of 9594 kg ha^{-1} (Anonymous, 2004).In Maharashtra area under okta cultivation is 9.3 thousand hactares with production of 120.5 thousand hactortonnes. Okra is grown practically in all agro ecological zones mainly for its immature fruits which are eaten as cooked vegetables or added to soups (Anitha *et al*., 2001).

Scheduling of nutrients at right time, in right amount, in right manner at right place, is the cru× of precision nutrient management. Micro irrigation, a technique that provides crops with water through a network of pipe lines at a high frequency but with a low volume of water (drips) applied directly to the root zone in a quantity that approaches consumptive use of the plants, can be combined with fertilizer application, to offer fertigation. Fertigation enables the farmer to meet the specific water and nutrient needs of the crops with great precision, thus minimizing losses of both precious water and nutrients. The direct delivery of fertilizers through drip irrigation demands the use of soluble fertilizers and pumping and injection systems for introducing the fertilizers directly into the irrigation system. Fertigation allows an accurate and uniform

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Table 1
Physico-chemical properties of soil at experimental site

Soil depth cm	Sand %	Silt %	Clay %	Textural class	Bulk density gcm^{-3}	Water retention at, cm^3cm^{-3} 0.33bar	15 bar	Saturated moisture content, cm^3cm^{-3}	K_s, cm day^{-1}	EC dS/m	pH
0-30	16	30	44	Clayey	1.36	0.35	0.18	0.40	22.10	4.09	8.7

application of nutrients to the wetted area, where the active roots are concentrated. The nutrients are applied as per the crop need at different growth stages in split manner. The problem of mobility of non-mobile nutrients is also addressed using fertigation. Planning the irrigation system and nutrient supply to the crops according to their physiological stage of development, and consideration of the soil and climate characteristics, result in high yields and high quality crops with minimum pollution.

Increase in crop yield in drip irrigation was reported to be 10 to 70 per cent over conventional method depending upon the crop (Sivanappan and Padmakumari, 1980; Jadhav *et al.*, 1990; Singandhupe et al, 1998; Brahmanand and Singandhupe, 2001). Increase in yield over surface irrigation system was also observed as 100% in Cucumber (Robbins, 1977) and 76% in cauliflower (Kadale *et al.*, 1990).The varying degree of water saving in drip over surface irrigation depending upon the crop and season (Ghumare and Kadam, 1991; Pandit, 1996; Singandhupe *et al.* 1998) were reported as 60 per cent in cotton (Taley and Shekar, 2001), 40 per cent in Arecanut (PDC, 2003); 25 to 46 per cent in potato (Brahmanand and Singandhupe, 2001; Prabhakar and Hebber, 1996), 67 per cent in coconut (Varadan *et al.*, 1991), 16 to 44 per cent in sugarcane (Selvaraj *et al.*, 1997), 50 to 70 per cent in other fruit crops (INCID, 1994) and 31 to 62 per cent in vegetables (INCID, 1994).

Table 2
Details of treatments

Sr. No.	*Treatments*	*Specification*
1.	I_1F_1	Irrigation at 0.4 PE and 50% RDF.
2.	I_1F_2	Irrigation at 0.4 PE and 75% RDF.
3.	I_1F_3	Irrigation at 0.4 PE and 100% RDF.
4.	I_2F_1	Irrigation at 0.6 PE and 50% RDF.
5.	I_2F_2	Irrigation at 0.6 PE and 75% RDF.
6.	I_2F_3	Irrigation at 0.6 PE and 100% RDF.
7.	I_3F_1	Irrigation at 0.8 PE and 50% RDF.
8.	I_3F_2	Irrigation at 0.8 PE and 75% RDF.
9.	I_3F_3	Irrigation at 0.8 PE and 100% RDF.
10.	Control	Conventional surface irrigation with 100% RDF through soil application

In India more than 4.0 Mha of land have been brought under pressurized irrigation (sprinkler and micro irrigation). Most of the crops irrigated under micro irrigation are horticultural crops. In this paper effort has been madeto optimize the best irrigation and fertigation schedules for increasing productivity of Okraat Research Farm of All India Co-ordinated Research Project on water management, Marathwada Agricultural University, Parbhani.

MATERIALS AND METHOD

Experimental Site

The e×periment was conducted during 2008-09 at research farm of All India Coordinated Research Project on Water Management, M.A.U., Parbhani. Geographically Parbhani is situated at an altitude of 409 m above the mean sea level in the central part of India and intersected by 76°47′ East longitude and 19°27′ North latitude. To characterize the soil at e×perimental plot, physico-chemical analysis of soil sample from 0-30cm depth was carried out and presented in Table 1.

Experimental Details

Field e×periment was planned comprising of four irrigation schedules and three levels of fertilizers through fertigation under drip irrigation. The e×perimental design was split plot and randomized block design in which all treatments were replicated four times. The treatments consisted of three drip irrigation schedules and one control whereas there were three fertilizer levels with recommended dose as 100:50:50 kg ha^{-1} of N: P_2O_5 and K_2O.The list of treatment combination was presented in Table 2.

Detail of Fertigation and Irrigation Scheduling

The crop water requirement depends upon the factors related to plant, soil and climate. For irrigation planning the knowledge of crop water needs representing the response to the atmospheric evaporative demand is necessary Rajput and Patel (2002).

Table 3
Schedule of fertilizer application according to crop growth stage (for 100% RDF)

			RDF (kg/ha)		
Sr. No.	*Growth stage*	*DAS*	*N*	*P*	*K*
1.	Initial growth stage	15	20	5	10
2.	Vegetative stage	30	20	10	10
3.	Flowering stage	45	20	20	5
4.	Flowering and fruiting stage	60	20	10	10
5.	Fruiting	75	20	5	15
	Total Application		100	50	50

Fertigation

The sources of major nutrients NPK used in the e×periment were water soluble fertilizers and applied through water using venturi applicator. The increase in the levels of fertilizers was found to improve the growth and yield. For Parbhanikranti variety of okra Singh and Singh (1999) reported increase in seed yield with increase in the fertilizer level upto 120 kg N/ha. A field e×periment on yield response of okra to different level of fertigation conducted by Rajput and Patel (2002) in cv. ArkaAnamika and observed that highest yield was obtained with fertigaion at 100 % recommended fertilizer rate *i.e.* 120:20:60 NPK kg/ha. The schedule of fertilizer application for drip irrigated plots during crop growth period is presented in Table 3.

Irrigation

The crop was irrigated by surface and drip method as per the treatments. For drip method, irrigation was scheduled at an alternate day. Initially cumulative pan evaporation (CPE) of two days was computed. For surface irrigated plots 6 cm depth of water was applied at 1.0 IW/CPE ratio through small furrows.Singh (1987) reported an increase in vegetative growth of okra with increase in irrigation amounts ranging from 40% to 100% of pan evaporation (PE). Under drip irrigation at 0.8 cumulative pan evaporation increase in sugarcane yield (9%) and water use efficiency (25.8%) as compared to surface flooding has also been reported (Malavia *et al.*, 2001).

(i) The quantity, of water required per plot in liters was computed by using the following equation:

$$Q = d \times L \times W \qquad \text{...(1)}$$

in which, Q = Volume of water to be applied (lit); L = Length of furrow (m); W = Width of furrow (m) and d = depth of water to be applied (mm).

(ii) The depth of irrigation is calculated by using following equation:

$$D = n \times CPE \qquad \text{...(2)}$$

in which, D = Depth of irrigation; n = compounding factor (representing crop coefficient and pan coefficient Kp = 0.7) and CPE = Cumulative pan evaporation of previous two days.

(iii) Volume of water to be applied per plot in drip is calculated by using the eq^n.

$$V = D \times A_C \qquad \text{...(3)}$$

in which, V = Volume of water applied (lit); D = Depth of water to be applied (mm) and A_C = Wetted Area.

(iv) Time of system operation was calculated with the help of following equation:

$$V = \frac{T}{q} \qquad \text{...(4)}$$

In which, T = Operation time of system (min); V = Volume of water applied (lit); and q = Emitter discharge (lph).

RESULTS AND DISCUSSION

The growth and yield characteristics of okra were periodically monitored and recorded during the crop growth period. A control treatment of conventional application of water and fertilizer (furrow irrigation at 1.0 IW/CPE with 60 mm depth and 100% RDF) was used for comparison. For comparison among drip irrigation treatments the two factor split plot design with irrigation schedule as main and fertigation levels as sub was used for data analysis. Whereas for comparison with control the data was analyzed in randomized block design with ten individual treatments.Aher (2003) observed that drip irrigated okra fruits and vegetables gave 11.23 to 43% increased yield as compared to surface method. Samnotra *et al.* (2002) observed that spring summer and rainy season crops of okra cv. ParbhaniKranti was maximum at 18 and 24 days after anthesis with fruit weight, fruit length and number of seed and maximum germination percentage was highest at 27-36 days after anthesis.

GROWTH CHARACTERISTICS

The crop growth characteristics of okra *viz.*, height of plantand number of leaves were monitored periodically during the crop growth period. The

Table 4
Effect of individual treatments on mean plant height and number of leaves of okra

Treatments	Mean plant height (cm)			No. of leaves		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
I_1F_1	26.0	42.0	61.5	9.3	22.8	31.5
I_1F_2	24.0	43.5	72.0	10.0	22.5	34.3
I_1F_3	26.0	45.0	82.3	10.3	23.5	30.8
I_2F_1	29.0	43.8	80.5	10.0	25.0	32.8
I_2F_2	24.7	42.0	74.5	8.5	21.8	29.3
I_2F_3	27.3	42.0	73.8	8.3	22.0	29.3
I_3F_1	29.5	47.3	82.0	11.8	26.3	36.0
I_3F_2	30.5	47.8	84.8	12.3	27.0	38.0
I_3F_3	31.0	45.8	84.0	10.0	22.8	34.8
I_4	25.7	41.5	60.5	8.5	15.8	28.0
Mean	27.4	44.0	75.6	9.9	23.0	33.8
SE ±	0.69	1.05	1.31	0.68	1.16	1.12
C.D. at 5%	2.01	3.05	3.80	1.98	3.38	3.23

Table 5
Effect of individual treatments on yield contributing characters

Treatments	Total fruit yield (t/ha)	Number of fruits/ plant	Avg. wt of fruits (g)	Perimeter of fruit (cm)	Length of fruit (cm)
I_1F_1	9.30	10.40	12.10	6.42	12.52
I_1F_2	12.77	12.02	14.55	6.93	14.25
I_1F_3	14.14	15.62	12.45	6.35	12.53
I_2F_1	13.82	13.80	13.78	6.71	13.21
I_2F_2	14.04	14.37	13.26	6.24	12.98
I_2F_3	13.36	14.39	12.78	6.35	13.01
I_3F_1	13.32	14.36	12.45	6.55	13.66
I_3F_2	14.87	15.47	13.64	6.64	13.64
I_3F_3	14.39	14.87	13.11	6.50	13.11
I_4	9.12	11.93	12.26	6.54	12.26
Mean	12.90	13.72	13.11	6.52	13.11
SE ±	0.58	1.24	0.40	0.15	0.40
C.D. at 5%	1.68	NS	2.27	NS	1.17

effect of individual treatments on mean plant height and number of leaves of okra was presented in Table 4. Data indicates that the mean plant height at increased at steady rate from 27.4 cm at 30 DAS to 44.0 cm at 60 DAS. After 60 days the mean plant height was increased rapidly to 75.6 cm at 90 DAS. The differences in the mean plant height due to treatment at all growth stages were significant. The ma×imum plant height was obtained in I_3F_2 (0.8 CPE mm depth and 75% RDF) which was 31.0, 47.8 and 84.8 cm respectively and found to be significantly superior over all other treatments. The minimum plant height was recorded in treatment I_4 (Surface irrigation method).

The number of leaves increased rapidly from 10 at 30 DAS to 22.8 at 60 DAS. After 60 DAS the increase in number of leaves was relatively at lower rates. The data also show that the numbers of leaves in all drip irrigated plots were higher as compared to surface control. The treatments I_3F_2 showed significantly higher number of leaves at 30, 60, 90 DAS as 12.3, 27 and 38, respectively and found to be significantly superior over all the treatments.

YIELD CONTRIBUTING CHARACTERS

Table 5 indicates that the effect of treatments on total yield of fruits is significant. All drip irrigated plots showed higher fruit yields as compared to furrow irrigated plot. Among the treatments I_3F_2 (0.8 PE and 75% RDF) showed significantly highest fruit yields of 14.87 t/ha over I_1F_1, I_1F_2 and I_4 treatments. Remaining all the treatments was at par with I_3F_3. The effect of individual treatments on mean number of fruits per plant was not significant. The treatment I_1F_3, I_2F_3, I3F2 and I3F3 show higher number of fruits as compared to other treatments. The number of fruits in surface irrigated plot was less as compared drip irrigated plots. However the interaction effect on average weight of fruit was significant. The treatments studied in this investigation could not show any significant differences on perimeter of okra fruit. However, all the drip irrigated treatments showed numerically higher fruit perimeter fruit as compared to surface irrigated plots. The fruit length was significantly higher in treatment I_3F_1 (13.66 cm) and I_3F_2 (13.64 cm). The minimum length of fruit was observed in surface irrigated plots.

CONCLUSION

The drip irrigated okra show better growth compared to surface irrigation.The drip irrigation schedule does not significantly affect the plant growth characteristics particularly mean plant height and number of leaves. However drip irrigation method scheduled at 0.8 CPE mm depth and 75% RDF showed higher values of plant height and number of leaves. This indicate that for the better plant growth of okra the lower amount of water 0.4 PE and fertigation level at 50% RDF were sufficient.For okra drip irrigation should be scheduled at 0.6 PE with 75% of RDF through water in five equal splits. Drip irrigation increases the okra fruit yield to the tune of 38.33%. The quality parameters such as number of fruits per plant and average weight of okra fruit do not change much with application of different amount of fertilizers and water through drip irrigation. However irrigation schedule at 0.6 PE and fertigation level of 75% give higher number of fruits per plant and average weight of fruit.The other quality parameters such as length of fruit and perimeter of fruit mostly depends on the time of harvesting. The drip irrigation schedule and fertigation levels do not alter these quality parameters. However the both length and perimeter of fruits are better under 0.8 PE and 75% fertigation levels.

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