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Response of okra to different levels of drip irrigation on growth, yield and water use efficiency

■ R. GANESH BABU, I. BHASKARA RAO AND K.N. RAJA KUMAR

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See end of the Paper for authors' affiliation

Correspondence to :

R. GANESH BABU
Department of Soil and Water Engineering, College of Agricultural Engineering, BAPATLA (A.P.) INDIA

■ **ABSTRACT :** A field experiment was conducted at College of Agricultural Engineering, Bapatla during *Rabi* 2014 to evaluate the response of different levels of irrigation through drip irrigation to find out appropriate irrigation level which leads to higher water use efficiency and yield of okra. The irrigation water was applied at 1.00 CWR (Crop water requirement), 0.80 CWR and 0.60 CWR through drip irrigation system. The crop water requirement was estimated for vegetable crops at study area as 516.3 mm during *Rabi* season using CROPWAT based on the climate data, rainfall data, crop data, cropping pattern data and soil data. Okra crop irrigated with drip irrigation at 0.80 CWR recorded the better growth *i.e.* good plant height and root length than the other treatments. Okra crop irrigated with drip irrigation at 0.80 CWR recorded the highest benefit cost ratio *i.e.* 3.15, which recorded 21.47 per cent more yield than the traditional method of irrigation and it was recorded the better water use efficiency as 0.143 t/ha-cm.

■ **KEY WORDS :** Okra, Drip irrigation, Different irrigation levels, CROPWAT

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Water is the crucial input for agriculture and the scarcity of water source is increasing at an alarming rate due to increasing cropping intensity, Industrial expansion and domestic needs. Okra (*Abelmoschus esculentus* L.) or Lady's finger is one of the important vegetables grown throughout the tropics and subtropics. India is the topmost country, producing 4.18 million tonnes of okra annually, which is around 70 per cent of global okra production (FAO, 2008). The nutritional value of 100 g of edible portion of okra contains 1.9 g protein, 0.2 g fat, 6.4 g carbohydrate, 0.7 g minerals and 1.2 g fibre (Gopalan *et al.*, 1989). Irrigation scheduling is considered as a vital component of water management to produce higher irrigation efficiency under any irrigation system, as excessive or sub-optimum irrigation both have detrimental effects on productivity parameters of okra (Aiyelaagbe and Ogbonnaya, 1996).In almost all regions of the world, water supply is the major constraint to crop production due to water demand for rapid industrialization and high population growth. The further scarcity of irrigation water for crop production should be checked for sustaining the food supply through efficient water conservation and management practices even in high rainfall areas (Panda *et al.*, 2004). Agricultural sector consumes about 83 per cent of water whereas, about 50-70 per cent of water is wasted through conveyance, evaporation, field application and distribution losses in conventional method of irrigation. These losses can be reduced by adopting drip irrigation method with efficient water management practices (Dahiya *et al.*, 2005). Hence, a field experiment was carried out on okra crop to assess the effect of different levels of irrigation

through drip irrigation.

METHODOLOGY

The detail methodology of the experiment like data collection, analysis and application of model to the study area has been discussed in the following heads:

A field experiment was conducted at College of Agricultural Engineering, Bapatla during *Rabi* 2014 to evaluate the response of different levels of irrigation through drip irrigation to find out appropriate irrigation level which leads to higher water use efficiency and yield of okra. The irrigation water was applied at 1.00 CWR (Crop water requirement), 0.80 CWR and 0.60 CWR through drip irrigation system. The results were compared with conventional method of irrigation.

Experimental site and climate :

The experiment was conducted at field irrigation laboratory with an area of 504 sq. m (24× 21 m) near the threshing floor and beside the mango orchard at the back of workshop building in College of Agricultural Engineering, Bapatla. Okra crop was selected to grow the crop for experimental investigations during *Rabi* season *i.e.* from second week of February to the second week of May, 2014. Geographically Bapatla is located at latitude of 160º N and longitude of 880º E with an altitude of 5 m above mean sea level. The experimental site lies in the humid sub-tropical area. The summer are dry and hot, whereas winter is cool. The experimental site consisted of sandy soil.

Preparation of the field for the experiment :

After clearing the land, primary tillage operations were done with a rigid tyne cultivator drawn by a tractor for the initial loosening of the soil and for removing the weeds. One ton of farm yard manure was applied throughout the field having an area of 504 sqm. at the recommended rate of 20 tones/ha and after one week again tilled with a tractor drawn rotavator, so that the dried farm yard manure thoroughly mixed with the soil.

Details of the experiment :

The area of the experimental plot was 504 sqm with size of 24m × 21m (Fig. A). The treatments consisted of three drip deficit irrigation regimes based on crop water requirement (CWR) *i.e.* 60, 80 and 100 per cent of CWR through drip irrigation and one conventional method of irrigation as control. The experiment was laid out in a Randomized Block Design with three replications. The details are given below :

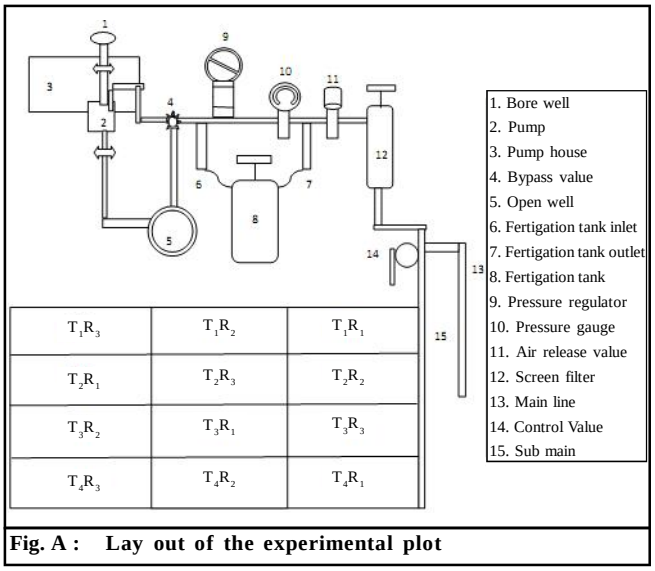

Fig. A : Lay out of the experimental plot

Details of treatments :

Plot size: 6m × 7m each plot

T_1= Drip irrigation at 0.60 CWR

T_2= Drip irrigation at 0.80 CWR

T_3= Drip irrigation at 1.00 CWR

T_4= Conventional method of irrigation (control).

Sowing of seeds :

Okra seed (Variety - research okra VNR-06) was sown with a spacing of 40 × 20 cm in paired row drip system. The sowing was done at 20 cm away from the lateral on both sides with 40cm row spacing and 20 cm plant spacing within the row having lateral spaced 1.2m apart.

Application of fertilizers and pesticides :

Initially at the time of land preparation, 1000 kg. of farm yard manure (FYM) was applied in the experimental plot and operated the rotavator to mix the FYM with soil thoroughly. During the crop growth period, fertilizers were applied as per the recommendation. The recommended dosage of fertilizers were applied through drip fertigation to the treatment T_1, T_2 and T_3 plots which were having drip irrigation system and manually applied to the treatment T_4 plot *i.e.* traditional irrigation method which was taken as control. Plant protection measures

were taken up as per the requirement in the experimental plots.

Application of water :

The irrigation water was applied as per the treatments *i.e.* 0.60 CWR, 0.80 CWR, 1.00 CWR through drip irrigation and full irrigation by traditional method for the control. Irrigation scheduling of okra crop for *Rabi* season was prepared as per the treatments using CROPWAT. Time of operation of the drip system for the different treatments was calculated and operated the drip system daily as per the irrigation schedule.

RESULTS AND DISCUSSION

The irrigation water was applied as per the treatments *i.e.* 0.60 CWR, 0.80 CWR, 1.00 CWR through drip irrigation and full irrigation by traditional method for the control. The results of the different treatments were compared with the traditional method of irrigation *i.e.* control.

Crop water requirement :

Estimation of the crop water requirement (ETc) was carried out by calling up successively the appropriate climate data, together with soil and crop data files and the corresponding planting dates. The crop water requirement was estimated for vegetable crops at study area as 516.3 mm during *Rabi* season and also estimated the crop water requirements at different growing stages of vegetable crops during *Rabi* season using CROPWAT based on the climate data, rainfall data, crop data, cropping pattern data and soil data and furnished in Table 1.

Irrigation scheduling :

Irrigation schedules were prepared for okra crop based on the climate data, crop data, cropping pattern

Table 1 : Crop water requirement for *Rabi* vegetable crops based on the historical weather data of Bapatla (Hear 1 dec is equal to 10 days)

Months	Dec.	Stage	Crop co-efficient Kc	ETc mm/day	ETc mm/dec	Effective rainfall mm/dec	Irr. Req. mm/dec
February	2	Init	0.70	3.19	28.7	0.0	28.7
February	3	Init	0.70	3.40	27.2	0.0	27.2
March	1	Deve	0.73	3.77	37.7	0.0	37.7
March	2	Deve	0.83	4.56	45.6	0.0	45.6
March	3	Deve	0.95	5.45	59.5	0.1	59.8
April	1	Mid	1.02	6.16	61.6	9.6	52.0
April	2	Mid	1.02	6.45	64.5	14.4	50.2
April	3	Mid	1.02	6.88	68.8	11.8	57.0
May	1	Late	1.00	7.16	71.6	6.4	65.2
May	2	Late	0.96	7.23	50.6	2.6	46.9
		Total			516.3	44.8	470.4

Table 2 : Irrigation scheduling for the okra crop during *Rabi* season

Months	Decade (10 days)	Stage of crop growth	CWR (ET_c) mm/day	Time of operation per day for drip system		
				T_1 0.60 CWR	T_2 0.80 CWR	T_3 1.00 CWR
February	2	Init	3.19	28 min	37 min	46 min
February	3	Init	3.40	29 min	39 min	49 min
March	1	Dev	3.77	33 min	44 min	54 min
March	2	Dev	4.56	40 min	56 min	1h - 05 min
March	3	Dev	5.45	47 min	1h - 03 min	1h - 19 min
April	1	Mid	6.16	53 min	1h - 11 min	1h - 20 min
April	2	Mid	6.45	56 min	1h - 15 min	1h - 33 min
April	3	Mid	6.88	60 min	1h - 19 min	1h - 40 min
May	1	Late	7.16	1h - 02 min	1h - 23 min	1h - 43 min
May	2	Late	7.22	1h - 03 min	1h - 24 min	1h - 44 min

data and soil data using CROPWAT model considering there is no rainfall during the crop period and furnished in Table 2. Time of operation of the drip irrigation system for the different treatments was calculated and operated the drip system daily as per the irrigation schedule. For the treatment T_4 which was taken as control, 5 cm of depth water was applied at weekly interval for 13 weeks throughout the crop period by traditional method.

Plant height :

The height of okra plant was measured at 15 days interval in four treatments. For recording the height of the plants, five plants were selected from each plot and taken the plant height. The observations on height of okra plants were collected and presented in Table 3. The average height of crop at the harvesting stage *i.e.* 75 DAS (Days after sowing) was observed as 36.1, 42.3, 42.6 and 40.3 cm for treatments T_1, T_2, T_3 and T_4, respectively.

Root length and roots distribution :

Root development in the terms of root length and roots distribution was observed by the digging of the soil until the tip of the root exposed. The results showed that the treatment T_2 and T_3 had good distribution of the root system (Table 4).

Yield response of okra with different levels of irrigation :

The total yield of okra for different treatments were calculated and presented in Table 5. The total yield obtained from the different treatments and is presented in Table 5 and Fig. 1. The yield from the treatment T_1 (0.60 CWR), T_2 (0.80 CWR) and T_3 (1.00 CWR) was observed as 4.07 t/ha, 5.94 t/ha and 6.33 t/ha, respectively. The yield was obtained from the control (Traditional irrigation method) was, 4.89 t/ha. The yield of the treatment T_3 was observed to be higher when compared to the yield obtained from the other irrigation levels. The higher yield can be obtained due to the efficient application of water and proper aeration in the root zone which helps for the favourable conditions for growth of the plant. Results revealed that there was no much difference in the yield from the treatments T_2 and

Table 3 : Plant height of the okra under the different levels of irrigation

Days after sowing	Plant height (cm)															
	T_1R_1	T_1R_2	T_1R_3	T_1 Ave	T_2R_1	T_2R_2	T_2R_3	T_2 Ave	T_3R_1	T_3R_2	T_3R_3	T_3 Ave	T_4R_1	T_4R_2	T_4R_3	T_4 Ave
15	4.2	4.1	5.2	4.5	4.2	4.2	5.0	4.5	5.2	4.9	4.0	4.7	8.0	5.8	4.3	6.0
30	5.6	5.3	6.8	5.9	7.2	7.6	9.0	7.9	13.0	15.2	8.3	10.1	16.2	15.8	10.2	14.0
45	12.8	11.3	16.1	13.4	20.9	22.4	19.2	20.8	24.0	27.4	13.8	21.9	21.6	20.4	18.4	20.1
60	26.8	18.2	30.2	25.0	29.6	33.4	28.6	30.5	28.8	33.6	38.2	30.8	38.6	36.8	27.6	34.3
75	42.2	29.4	36.8	36.1	34.4	41.0	51.6	42.3	36.2	42.8	53.5	42.6	48.2	46.2	28.6	40.3

Table 4 : Root length of the okra under the different levels of the irrigation

Sr. No.	Treatments	Root length (cm) in replications			Average root length (cm)
		R_1	R_2	R_3	
1.	T_1	19	23	21	21
2.	T_2	40	44	36	40
3.	T_3	35	39	34	36
4.	T_4	41	33	28	34

Table 5 : Yield of the okra under different levels of the irrigation

Sr. No.	Treatments	Yield (t/ha)			Average yield (t/ha)	% of increase in yield
		R_1	R_2	R_3		
1.	T_1	3.90	4.10	4.21	4.07	- 16.70 %
2.	T_2	5.91	6.10	5.81	5.94	21.47 %
3.	T_3	6.32	6.51	6.17	6.33	29.35 %
4.	T_4	4.82	4.93	4.92	4.89	–

T_3. It indicates the effect of 20 per cent reduction in the crop water requirement on the yield of the okra was very less but 40 per cent of reduction in the crop water requirement gave the negative impact on the yield of the okra (-16.7 %) might be due to applied water to the treatment T_1 was not sufficient for the crop growth.

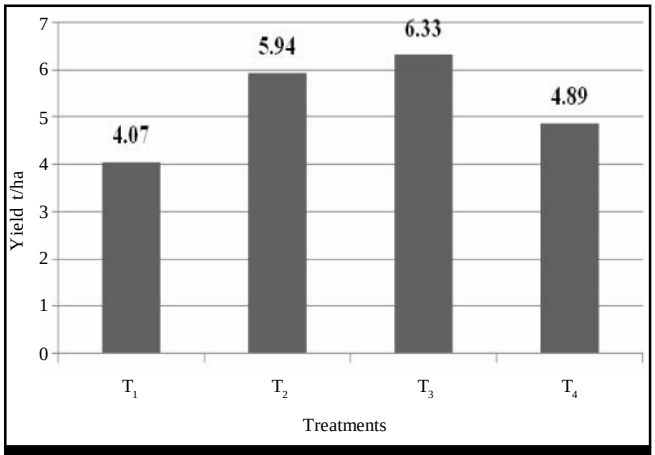

Fig. 1 : Response of deficit irrigation levels on okra crop

Water use efficiency :

Water use efficiency of the different treatments was calculated and furnished in Table 6 and Fig. 2. The results of water use efficiency stated that the treatment T_2 *i.e.* deficit irrigation water level at 0.80 CWR was the best among all other treatments. The deficit irrigation water level at 0.80 CWR is recorded high water use efficiency as 0.143 t/ha-cm and followed by the treatments T_1 and T_3 recorded as 0.131 and 0.122 t/ha-cm, respectively. In the treatment T_4 which was taken as control recorded the poor water use efficiency as 0.075 t/ha-cm. Through adoption of the drip irrigation system water can be saved

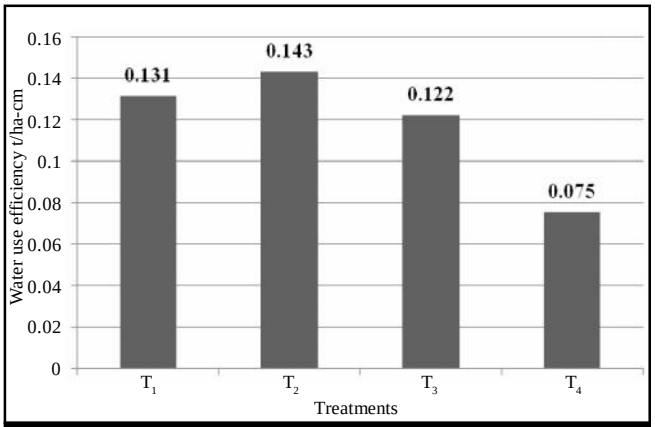

Fig. 2 : Water use efficiency (WUE) of okra under different levels of irrigation

Table 6 : Water use efficiency (WUE) of the okra crop under the different levels of the irrigation

Sr. No.	Treatments	Water applied (mm)	Saving of water (%)	Water use efficiency (t/ha-cm)
1.	T_1	309.8	52.3 %	0.131
2.	T_2	413.0	36.5 %	0.143
3.	T_3	516.3	20.6 %	0.122
4.	T_4	650.0	–	0.075

Table 7: Cost economics of okra crop under deficit irrigations

Sr. No.	Particulars	T_1	T_2	T_3	T_4
1.	Annual cost (Depreciation, interest, repair and maintenance)	28500	28500	28500	---
2.	Cost of cultivation (FYM, seed, fertilizers and pesticides, including labour charges)	23000	23000	23000	55000
3.	Seasonal total cost (1+2) Rs./ha	51500	51500	51500	55000
4.	Water used (mm)	309.8	413.0	516.3	650.0
5.	Yield produced (t/ha)	4.07	5.94	6.33	4.89
6.	Yield extra by using saved water (t/ha)	2.04	2.17	1.30	---
7.	Total yield obtained (t/ha) (5+6)	6.11	8.11	7.63	4.89
8.	Selling price (Rs./t) @Rs. 20/kg	20000	20000	20000	20000
9.	Income from produce (7x8) Rs.	122200	162200	152600	97800
10.	Net seasonal income (9-3) (Profit)	70700	110700	101100	42800
11.	Benefit cost ratio (9/3)	2.37	3.15	2.96	1.78

which increases the cropped area by irrigating with the saved water (Chaudhari *et al.*, 2010 and Barua, 2013).

Cost economics :

The net seasonal income from drip at 80 per cent CWR was maximum *i.e.* Rs. 1,10,700 followed by 100 per cent CWR with Rs. 1,01,100 whereas in 60 per cent CWR and control was Rs. 70,700 and Rs. 42,800, respectively as shown in the Table 7.

Highest cost benefit ratio was recorded as 3.15 for the treatment T_2 *i.e.* drip irrigation at 0.80 CWR followed by 2.96 with T_3 drip irrigation at 1.00 CWR. Lower benefit cost ratio of 1.78 was recorded with traditional irrigation method (T_4).

The results of the crop water requirement were estimated with the help of CROPWAT model and confirmation with the Smith (1992) and the results on the response of okra crop for different irrigation levels are in confirmation with Muthukrishnan and Fanish (2011), Abd El-Kader *et al*. (2010) and Bhanu Rekha *et al*. (2005). The conveyance and application losses were reduced in drip irrigation method and daily application of water with low discharge facilitated the aeration in the soil for its growth period. The results revealed that the drip irrigation saved water upto 36.5 per cent without any significant difference in the yield and got higher water use efficiency (Rao *et al*., 2010; Gupta *et al*., 2010; Methi, 2012). The increase in water use efficiency has led to increase in additional area under cultivation by using saved water through drip irrigation and increased the gross income and net profit (Popale *et al.*, 2011 and Murali *et al*., 2014).

Conclusion :

Based on the study, okra crop irrigated with drip irrigation at 0.80 CWR recorded the highest benefit cost ratio (3.15) which recorded 21.47 per cent more yield than the traditional method of irrigation and also it recorded the better water use efficiency as 0.143 t/ha-cm.

Authors' affiliations:

I. BHASKARA RAO, Department of Soil and Water Engineering, College of Agricultural Engineering, BAPATLA (A.P.) INDIA

K.N. RAJA KUMAR, Department of Agricultural Structures, College of Agricultural Engineering, BAPATLA (A.P.) INDIA

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