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Response of Yield and Growth Parameter of Okra (*Abelmoschus esculentus* L.) under Drip Irrigation with Different Lateral Spacing

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ABSTRACT

A field experiment was conducted at CCS HAU, Hisar during summer season of 2019 and 2020 to study the response of okra (*Abelmoschus esculentus* L.) under drip irrigation with different lateral spacing and irrigation frequency. Two lateral spacing (L_1-45 cm and L_2-60 cm) and two irrigation frequencies (I_1-daily and I_2-alteranate day) were evaluated in the split plot design with three replications. Two year pooled data showed that maximum plant spread (1764.5 cm^2), height (114.5 cm) and primary and secondary branches (3.6 and 5.4) were observed with daily irrigation under 45 cm lateral spacing. The maximum yield (111.9 q/ha) and marketable yield (104.9 q/ha) of okra was also observed with daily irrigation under 45 cm lateral spacing. Maximum (69.9 kg/kg) and minimum (64.8 kg/kg) FUE in okra was recorded in lateral spacing 45 cm with daily irrigation and lateral spacing 60 cm with alternate day irrigation, respectively. Maximum (14.1 kg/m^3) and minimum (13.1 kg/m3) WUE in okra was recorded in lateral spacing 45 cm with daily irrigation and lateral spacing 60 cm with alternate day irrigation, respectively. Statistically, okra growth and yield under daily irrigation with lower spacing was significantly higher than the other alternate day irrigation with higher lateral spacing.

Keywords Okra, Drip irrigation, Lateral spacing, Irrigation frequency.

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INTRODUCTION

Water supply is a major constraint to crop production in arid and semi arid region of India. Efficient use of irrigation water is becoming very important, and alternative water application methods such as drip, subsurface drip, sprinkler and micro sprinkler may contribute substantially to the best use of water for agriculture production and improving irrigation efficiency. Drip irrigation is the key to get higher production with low application of water. In the current scenario of decreasing fresh water resources due to globalization and industrialization, water availability for irrigation is become very limited. Optimum and efficient use of water for irrigation is possible with the use of drip irrigation. Drip irrigation wetted limited zone of soil profile just below the dripper where root of the plants are concentrated. So the availability of water and fertilizer (mixed with water) for the plants become maximum that enhanced the growth and yield of plants. In drip irrigation, lateral spacing is one of the deciding factors for the growth and development of the plant. Too close spacing reducing the growth of the plant due to overlapping of branches and leafs whereas too far spacing reduces the yield due to less number of plants in the field. In drip irrigation, closer lateral spacing usually gives greater horizontal water content distribution uniformity, yield and water use efficiency (Chen *et al*. 2015). Drip irrigation does not only conserve water but also improve productivity and quality of the product even utilizing poor quality waters. Optimum spacing should be maintained for fully utilization of the field and get maximum benefits from production of crop. Drip irrigation may achieve higher field application efficiency of 80-90%, as surface runoff and deep percolation losses are minimized (Postel 2000). Micro irrigation is the slow application of water in discrete or continuous way in the form of drops, tiny streams or miniature spray on, above, or below the soil by surface drip, subsurface drip, bubbler and micro-sprinkler. Drip irrigation save a healthy amount of water with good yield. 60.1% higher yield of okra with water saving of 39.5% under drip irrigation as compared to conventional furrow irrigation was reported by Rahuri, India, Khade (1987). Irrigation in controlled manner is very essential for high yield for vegetables and crops. Plants are very sensitive for both under as well as over irrigation ((Al-Harbi *et al.* 2008). Okra is a high water crop use despite having considerable drought resistance (Fasina *et al.* 2008). Different climatic region and soil condition affect the yield and growth of okra under drip irrigation. Hence, present work was undertaken to study the response of okra under drip irrigation with lateral spacing and irrigation frequency.

MATERIALS AND METHODS

Experiment was conducted at the Research field of soil and water engineering at Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experimental site is located at 29008’36.33’’N latitude and 75042’17.1’’E longitude with an elevation of about 217 m above the mean sea level. The present study was carried out in raised brick lined micro-plots with open bottom and inside dimension of 2 x 2 m, filled with loamy sand protected with wire mesh to prevent any damage by animals, birds. Design of micro plot was split plot design and each treatments consisted three replications. Experiment consisted two lateral spacing (45 cm and 60 cm), two plant spacing (40 cm and 30 cm) and two irrigation frequency (I_1- daily and I_2- alternate day). L_1- lateral spacing of 45 cm, L_2- lateral spacing of 60 cm and two plants spacing i.e. 40 cm and 30 cm. Total four combinations of treatments (L_1I_1, L_1I_2, L_2I_1 and L_2I_2) were taken for the evaluation of okra under drip irrigation. An Automated drip irrigation system was installed for irrigation application and irrigation water was applied on the basis of 100 % cumulative pan evaporation. From the cumulative pan evaporation, Crop evapotranspiration (ETc) was estimated by using equation (1).

$$ET_c = K_c \times K_p \times PE \quad (1)$$

Where, K_c = Crop coefficient values
K_p = Pan coefficient
PE = cumulative pan evaporation

Volume of water applied was calculated by following formula (Kaulage 2017),

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

Where, V = volume of water applied (liter/day/emitter),

L_s = lateral spacing
E_s = emitter spacing
W_a = wetted area factor (0.7) (Mane and Magar 2008)
EU = Emission uniformity of the system (90 %)

Plant height, plant spread, number of primary and secondary branches, number of pods per plants, pods length, pods weight and yield were recorded. For the statistical analysis OPSTAT software developed by CCS HAU, Hisar was used (Sheoran 2010).

RESULTS AND DISCUSSION

Water dynamics

At 15-30 cm depth just below the dripper moisture

Table 1. Moisture content at different depth and radial distance under drip irrigated okra for different treatments.

Treatments	Depth (cm)	30 DAS Radial distance (cm)			60 DAS Radial distance (cm)			90 DAS Radial distance (cm)		
		0	15	30	0	15	30	0	15	30
	0-15	14.62	13.47	12.13	14.33	13.20	11.89	13.90	12.81	11.53
L_1I_1	15-30	14.37	13.20	12.24	13.81	13.62	12.17	13.64	13.10	11.90
	30-45	12.03	11.83	10.70	11.20	11.45	10.49	11.40	11.23	10.25
	45-60	11.45	11.33	10.20	11.20	11.10	10.01	10.85	10.77	9.73
	0-15	14.10	13.06	11.10	13.80	12.78	10.89	13.38	12.40	10.55
L_1I_2	15-30	13.85	12.80	11.52	13.57	12.64	11.29	13.12	12.26	10.87
	30-45	12.52	11.59	10.35	12.10	11.36	10.14	11.86	11.02	9.81
	45-60	12.89	11.92	10.61	12.75	11.68	10.40	12.25	11.33	10.09
	0-15	14.58	13.11	11.65	14.31	12.82	11.45	13.87	12.39	11.05
	15-30	14.32	12.82	11.38	14.03	12.55	11.82	13.61	12.09	11.47
L_2I_1	30-45	12.01	10.52	10.34	11.73	10.25	9.72	11.36	9.90	9.36
	45-60	11.40	9.95	9.57	11.16	10.02	9.36	10.82	9.34	8.96
L_2I_2	0-15	14.03	12.58	11.31	13.76	12.25	11.04	13.35	11.84	10.64
	15-30	13.78	12.65	11.05	13.55	12.21	10.54	13.03	11.62	10.51
	30-45	12.49	10.97	9.85	12.22	10.74	9.55	11.85	10.36	9.21
	45-60	12.78	11.35	10.16	12.71	11.25	9.95	12.23	10.75	9.58

content was recorded as14.37,13.85,14.32 and 13.78% after 30 DAS,13.81, 13.57, 14.03 and 13.55% after 60 DAS and 13.78,13.12, 13.61 and 13.35% after 90 DAS was observed. At 45-60 cm depth just below the dripper moisture content was 11.45, 12.89, 11.40 and 12.78% after 30 DAS, 11.20, 12.75, 11.16 and 12.71% after 60 DAS and 10.85, 12.25, 10.82 and 12.23% after 90 DAS was observed. (Table 1)

Water dynamics graph were prepared using surfer software to see the distribution pattern of moisture content after 30 DAS, 60 DAS and 90 DAS is shown in Figs. 1 to 4 given below. Figs. 1 to 4 show the moisture movement during the cropping season of the okra. At the depth of 20 cm from the soil surface just below the dripper moisture content 14.4, 13.9, 14.3 and 13.8% after 30 DAS, 13.9, 13.6, 14.1 and 13.5% after 60 DAS and 13.7, 13.1, 13.7 and 13.1% after 90 DAS was observed. At 45 cm depth just below the dripper moisture content 11.7, 12.5, 11.6 and 12.7%

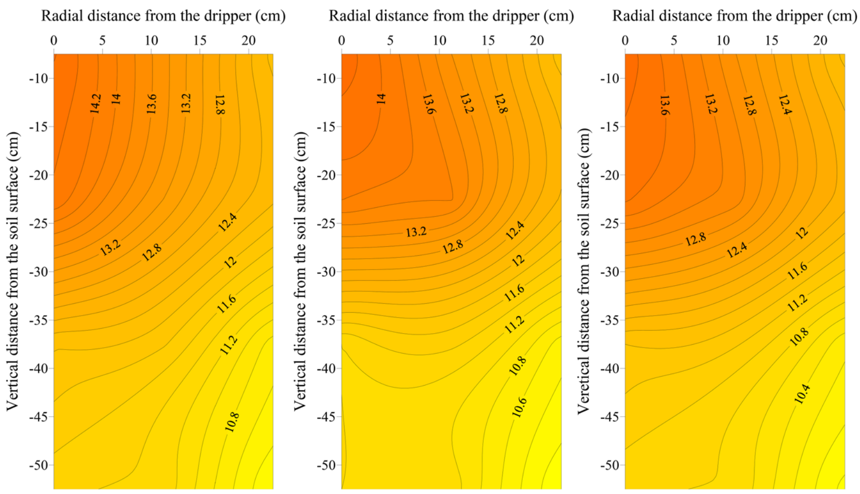

Fig. 1. Water distribution after each 30 , 60 and 90 DAS in L_1I_1 treatment.

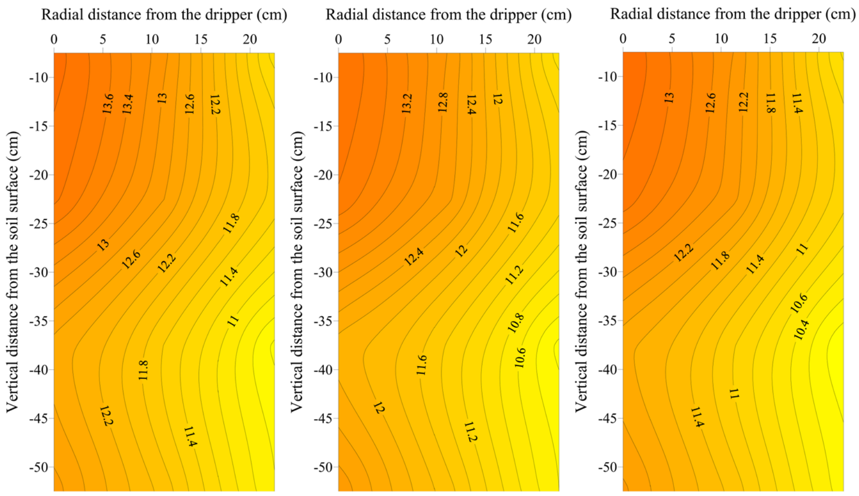

Fig. 2. Water distribution after each 30 , 60 and 90 DAS in L_1I_2 treatment.

after 30 DAS, 11.1, 12.3, 11.3 and 12.3% after 60 DAS and 11.1, 12.0, 10.9 and 11.9% after 90 DAS was observed. Pattern of decreasing moisture content was observed from initial stage to harvesting stage, indicating that with the development of plant, water uptake was increased that favours the decreasing pattern of moisture content. Maximum moisture content was observed in the lateral spacing 45 cm with daily irrigation treatments. Badr *et al*. (2013) also observed that the distribution efficiency of irrigation water is more efficient in less lateral spacing than in higher lateral spacing.

Growth and yield attributes

Spread of okra plants varied significantly and ranged from 1398.6 cm^2 to 1764.5 cm^2 (Table 2). The highest spread (1764.5 cm^2) of plant was found in lateral spacing 45 cm with daily irrigation treatment followed by lateral spacing 45 cm with alternate day irrigation treatment whereas lower plant spread (1398.6 cm^2) was observed with lateral spacing 60 cm with

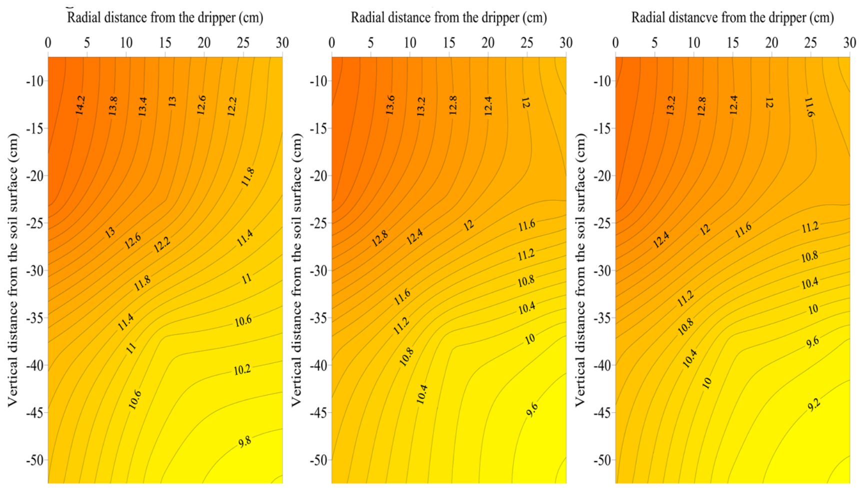

Fig. 3. Water distribution after each 30 , 60 and 90 DAS in L_2I_1 treatment.

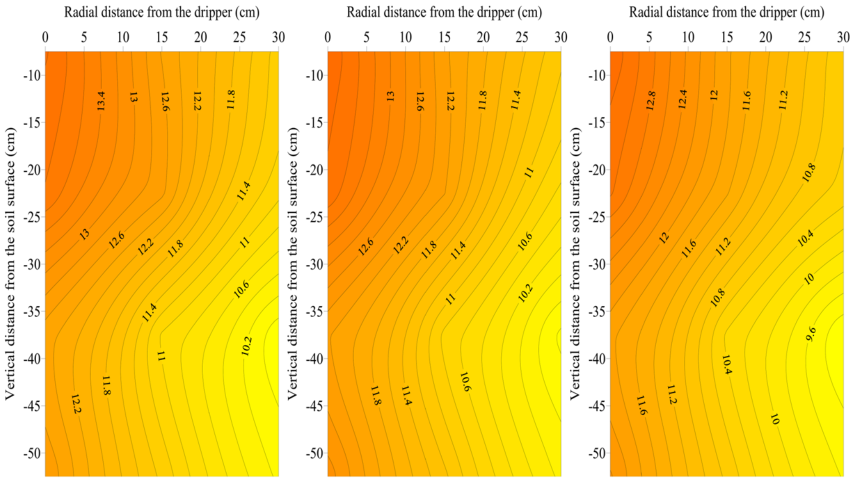

Fig. 4. Water distribution after each 30, 60 and 90 DAS in L_2I_2 treatment.

alternate days irrigation treatment. Plant spread was slightly more in N-S direction than the E-W direction due to presence of sunlight more in this direction. Maximum primary (3.6) and secondary branches (5.4) were observed with lateral spacing 45 cm with daily irrigation treatment and minimum primary (3.0) and secondary branches (4.3) were observed with lateral spacing 60 cm with alternate days irrigation treatment (Table 2). Maximum plant spread leads the maximum number of primary and secondary branches. Amoo *et al.* (2019) also favoured the result obtained during the experiment.

Maximum plant height was observed with lateral spacing 45 cm than lateral spacing 60 cm with drip irrigation. After 90 DAS, maximum plant height (114.5 cm) was observed in lateral spacing 45 cm with daily irrigation treatment whereas minimum average plant height (98.0 cm) was observed with lateral spacing 60 cm with alternate day irrigation treatment (Table 3). Daily irrigation with lower lateral spacing resulted in 2.91, 9.52 and 14.41% increase in plant height than the lateral spacing 45 cm with alternate day irrigation, lateral spacing 60 cm with daily irrigation and lateral spacing 60 cm with alternate day irrigation, treatments respectively. Similar result was also reported by Al-Ubaydi *et al*. (2017).

Number of pods per plants was maximum (22.3) in lateral spacing 45 cm with daily irrigation treatment and minimum (20.7) in lateral spacing 60 cm with alternate day irrigation treatment. In lateral spacing 45 cm with daily irrigation treatment, number of pods per plants was significantly higher than other three treatments. Pod length and pod weight was significantly more in the lateral spacing 45 cm with daily irrigation treatment than other three treatments.

Table 2. Plant spread and number of branches of okra plant effected by various treatments.

Treat-ments	N-S (cm)	E-W (cm)	Plant spread (cm^2)	Primary branches	Secondary branches
L_1I_1	63.7	55.4	1764.5	3.6	5.4
L_1I_2	62.9	55.0	1729.8	3.3	5.0
L_2I_1	58.2	52.6	1530.7	3.3	4.7
L_2I_2	55.5	50.4	1398.6	3.0	4.3
CD (p=0.05)			65.1	N/A	N/A

Table 3. Plant height, number of pods, pod length and pod weight of the okra as affected by various treatments.

Treatments	Plant height (cm)	Pods per plants	Pod length (cm)	Pod weight (g)
L_1I_1	114.5	22.3	10.1	8.08
L_1I_2	111.2	21.4	9.8	7.59
L_2I_1	103.6	21.0	9.6	7.40
L_2I_2	98.0	20.7	9.4	7.15
CD (p=0.05)	N/A	0.8	0.2	0.46

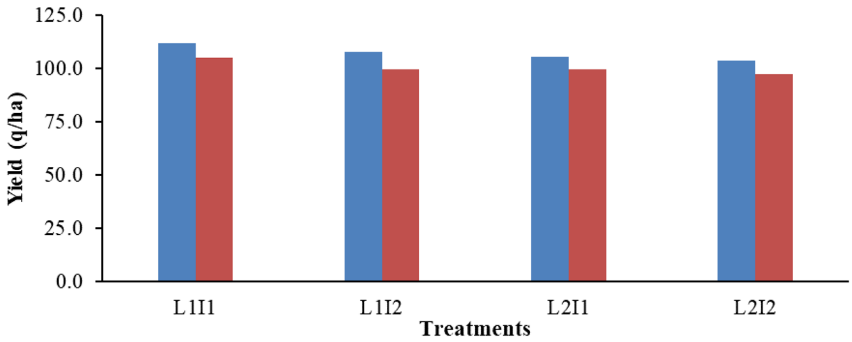

Fig. 5. Yield (q ha^{-1}) and marketable yield (q/ha) obtained under different treatments.

Maximum yield (111.9 q/ha) of okra was obtained with lateral spacing 45 cm with daily irrigation treatment whereas minimum yield (103.8 q/ha) in lateral spacing 60 cm with alternate day irrigation treatment (Table 3). Yield obtained in daily irrigation treatment was more due to higher moisture content. Drip irrigation with frequent irrigation replenishes water in the root zone that enhances the plant growth of the plant. Thokal *et al*. (2020) also reported the similar result. Maximum marketable yield (104.9 q/ha) was observed with lateral spacing 45 cm with daily irrigation treatment and minimum (97.2 q/ha) was observed with lateral spacing 60 cm with alternate day irrigation treatment. (Fig. 5).

Maximum FUE (69.9 kg/kg) was observed with lateral spacing 45 cm with daily irrigation treatment whereas minimum (64.8 kg/kg) with lateral spacing 60 cm with alternate day irrigation treatment (Table 4). Within the same lateral spacing FUE was non-significant whereas in same irrigation frequency with different lateral spacing FUE was significantly differ.

Table 4. Yield, Marketable yield, Fertilizer use efficiency and Water use efficiency of okra as effected by various treatments.

Treatments	Yield (q/ha)	Marketable yield (q/ha)	FUE (kg/kg)	WUE (kg/m^3)
L_1I_1	111.9	104.9	69.9	14.1
L_1I_2	107.7	99.8	67.3	13.6
L_2I_1	105.6	99.8	66.0	13.3
L_2I_2	103.8	97.2	64.8	13.1
CD (P=0.05)	4.5	4.3	2.9	0.5

Water use efficiency ranged from 13.1 to 14.1 kg/m^3. Maximum water use efficiency (14.1 kg/m^3) was observed with lateral spacing 45 cm with daily irrigation treatment and minimum water use efficiency (13.1 kg/m^3) with lateral spacing 60 cm with alternate day irrigation treatment.

On the basis of soil water dynamics, during cropping season higher moisture content was observed in the lateral spacing 45 cm with daily irrigation treatment. Maximum plant growth, plant height, yield, FUE and WUE was observed with lateral spacing 45 cm with daily irrigation frequency. Lateral spacing had significant effect on plant growth and yield with different irrigation frequencies.

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