RESEARCH ARTICLE OPEN ACCESS

Growth and Yield attributes of Okra under Influence of Drip Irrigation

Puneet Sharma[1], Arun Kaushal[2], Angrej Singh[3] and Sunil Garg[4]
[1,2,3,4] (Department of Soil and Water Engineering, Punjab Agricultural University Ludhiana, India)

ABSTRACT
To observe growth and yield attributes of Okra under effect of different irrigation and fertilizer levels with drip irrigation, a field experiment was carried out in 2014. The study consisted of three levels of Nitrogen fertilizers i.e. F_1-60%, F_2-80% and F_3-100% of Recommended dose of Fertilizer N and three drip irrigation levels I_1-60%, I_2-80% and I_3-100% of cumulative pan evaporation. Plant population after 40, 80 and 120 days of sowing was maximum in F_2I_2 treatment 96.1%, 86.7% and 82.2% respectively. Plant height after 40, 80 and 120 days of sowing was maximum in F_2I_2 treatment 48.73 cm, 98.07 cm and 145.07 cm respectively. Days to first flowering were minimum in F_2I_2 treatment (39.97 days). Days to fruit initiation and Days to fruit maturity were minimum in F_3I_2 treatment (45.49 days) and (48.1 days), respectively. Fruit number per plant, Fruit length and Fruit volume were observed to be maximum in F_2I_2 treatment (18.67), (10.83 cm) and (19.77 cm^3), respectively and minimum in F_1I_1 treatment (11.73), (7.6 cm) and (13.03 cm^3), respectively. Okra yield was maximum in F_2I_2 treatment (15.89 t/ha) and minimum in F_1I_1 treatment (10.68 t/ha). There was significant effect of irrigation, fertilizer and combination on okra yield.
***Keywords*:** Drip irrigation, Fertilizer ,Okra, Yield, Yield attributes

I INTRODUCTION

In India, Okra popularly known as lady finger or Bhindi is one of the most important vegetables from agricultural point of view. In India, production of okra during year 2013-14 was 6346.4 Thousand MTonnes [1]. Average area under total vegetable cultivation in Punjab during 2013-14 was 203.73 thousand hectare, out of which okra cultivation was reported to be 3.20 thousand hectare, whereas average yield and production of okra in Punjab was reported to be 10409 kg per hectare and 33.35 thousand tonnes [2], respectively. Okra is a crop of tropical and subtropical climate. The crop growth is vigorous during rainy season compared to spring summer. Seeds of okra fail to germinate below 20^0C temperature and optimum temperature for seed germination is 29^0C. Okra can be grown in all types of soils, but the soil should be friable. However, it grows best in light soils ranging from sandy loam to loam. [2].

Water is an essential requirement in agricultural production. In arid and semi-arid regions of India, water availability is becoming a major challenge of farm production. Water resources in India at present face many challenges, including increasing demands in many sectors. Maximum stress created directly or indirectly is due to agriculture sector [3].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. Thus, a scientific and efficient management of water is needed especially in hot dry months of pre monsoon period, to enhance water use efficiency and yield of crop. Drip irrigation is the technique in which roots of plants are supplied with water at specific rate.

Optimum moisture supplied by trickle method compared to surface method in mulched condition enhancing yield attributes and yield provides advantage of drip system over furrow method in [4]. [5] indicated that by drip irrigation system along with mulching, the yield of okra may increase upto 61% higher than surface irrigation method with same quantity of irrigation water applied. During the year 2009 and 2010, 13.6 and 14.8 percent higher okra yield was observed under drip irrigation in comparison to flood irrigation method as reported by [6]. [7] indicated that drip irrigation may help in producing more water applied and allow crop cultivation in water scarce area.

II MATERIALS AND METHODS

To study growth and yield attributes of Okra under effect of different irrigation and fertilizer levels with drip irrigation, a field experiment was carried out sandy loam soils at the experimental field of Department of Soil and Water Engineering, PAU, Ludhiana, in 2014-15. The study consisted of three levels of Nitrogen fertilizers i.e. F_1-60%, F_2-80% and F_3-100% of Recommended dose of Fertilizer N and

three drip irrigation levels I_1-60%, I_2-80% and I_3-100% of cumulative pan evaporation. For comparison, there was a control treatment of conventional surface irrigation method as practiced by farmers of Punjab for Okra cultivation [1].

Tillage, planking and levelling operations were performed properly on the soil surface. 50 cm wide beds were prepared with a spacing of 50 cm in between each bed. For control, ridges were prepared with 45 cm ridge spacing. Drip laterals were laid in between two rows of okra plants with inline drippers at a spacing of 20 cm. The drip irrigation system components were laid according to experimental design. Seeds of okra variety 'Punjab-8'were sown, as per the recommended seed rate of 25 kg/ha [1]. For drip fertigation treatments sowing was done at spacing of 34 cm X 20 cm within each row. For the control treatment, the seeds were sown on 45 cm X 15 cm ridges spacing.

For the experimental treatments, three fertilizer doses were based on recommended dose of fertilizer i.e. 200 kg/ha of urea was used in drip fertigation. For control, urea was applied as per requirement of okra grown by conventional method i.e. 50% dose applied at sowing and remaining as top dressing after first picking as recommended by PAU, Ludhiana i.e. 200 kg/ha of urea [1]. Irrigation was given on at the gap of one day and fertigation was given at alternative irrigation. In drip fertigation treatment fertilizers was applied in equal splits.

2.1 Growth Parameters

Selection and tagging of randomly selected five plants was done in each treatment for observing various crop parameters. By counting the number of plants at regular time intervals (40 days) at 40, 80 and 120 days after sowing in each experimental treatment; plant population was determined. Heights of the selected plants were taken at regular intervals (40 days) viz. 40, 80 and 120 days after sowing. Plant height was measured in centimeter from the plant base to the growing tip with the help of measuring scale and an average value was computed for each treatment. Numbers of days taken from the sowing date to date when first flower opened of the selected plants were noted as days to flowering and average days to flowering were computed for each experimental treatment. Numbers of days taken from the sowing date to development of the first fruit of each of the five selected plants were noted as days to fruit initiation and average days to fruit initiation computed for each experimental treatment. Number of days taken from the sowing date to date when first fruit mature for the selected plants was noted as days to fruit maturity and average days to fruit maturity was computed for each experimental treatment.

2.2 Yield and Yield Attributes

In each treatment, fruits harvested in each picking were noted down from five already selected plants. The following observations were noted and averages were computed. Counting of fruits harvested from each of the selected plants in every experimental treatment was done till the final harvest. The average number of fruits per plant in every plot was computed. Three fruits were randomly selected during each picking from the selected plants and length was measured by using measuring ruler in centimeters. The average length of fruit was computed and noted in centimeters. The fruit volumes of the same three randomly selected fruits used for measuring fruit length were measured by using measuring cylinder in cubic centimeter. The volume was measured by noting rise in level of water after complete immersion of fruits in it and its average was computed. Total weight of harvested fruits from each experimental treatment during each picking was noted till the final harvest and the total yield of fruits per hectare under different treatments were computed.

III RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant population

Plant population results obtained under combination of three different fertilizer levels and three drip irrigation levels at 40, 80 and 120 days after sowing are illustrated in Fig. 1. Plant population results after 40 days of sowing under drip fertigation combination treatments showed that maximum average plant population was in F_2I_2 treatment (96.1%) followed by F_3I_2 (93.3%) treatment which are statistically at par with all other drip fertigation combination treatments, whereas minimum plant population was observed in F_1I_1 treatment (81.7%). Considering only the effect of fertilizer levels, F_3 treatment was the best followed by F_2 and F_1. F_3 treatment is statistically at par with F_2 treatment, but both are significantly better than F_1 treatment. Also, considering irrigation levels only, I_2 was the best followed by I_3 and I_1. I_2 treatment is statistically at par with I_3 and I_1 treatments. Plant population under control treatment was 82.67%.

Plant population results after 80 days of sowing under drip fertigation combination treatments showed that maximum average plant population was in F_2I_2 treatment (86.7%) followed by F_3I_2 treatment (86.7%) which are statistically at par with all other drip fertigation combination treatments, whereas minimum plant population was obtained in F_1I_1 treatment (74.4%). Considering only the effect of fertilizer levels, F_3 treatment was the best followed by F_2 and F_1. F_3 treatment is statistically at par with F_2 treatment, but F_3 is significantly better than F_1 treatment. Also, considering irrigation levels only, I_3

was best followed by I_2 and I_1. I_2 treatment is statistically at par with I_3 but both are significantly better than I_1 treatments. Plant population under control treatment was 77%.

Plant population after 120 days of sowing under drip fertigation combination treatments showed that maximum average plant population was in F_2I_2 treatment (82.2%) followed by F_3I_2 treatment (81.75%) which are statistically at par with all other drip fertigation combination treatments, whereas minimum plant population was obtained in F_1I_1 treatment (68.3%). Considering only the effect of fertilizer levels, F_2 treatment was the best followed by F_1 and F_3. F_2 treatment is significantly better than F_1 treatment and F_1 treatment is significantly better than F_3 treatment. Also, considering irrigation levels only, I_2 was best followed by I_3 and I_1. I_2 treatment is statistically at par with I_3 but I_2 is significantly better than I_1 treatments. Plant population under control treatment was 68.3%. [8] also reported similar types of results regarding plant population. The main reasons for decrease in plant population of Okra crop despite of precautions could be because of pest attack, virus attack, less irrigation, less fertilizer etc.

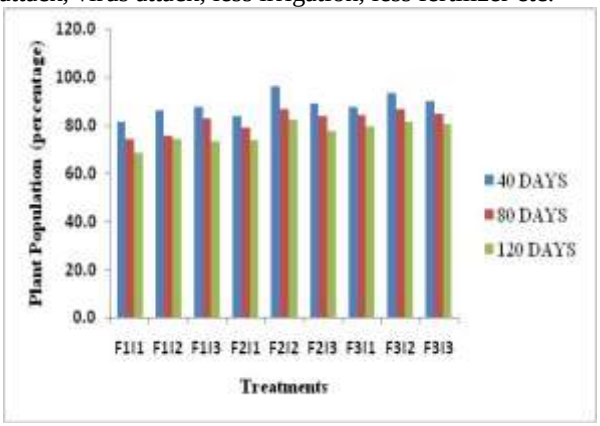

Fig. 1 Plant population under different treatments

3.1.2 Plant height

Plant height results obtained under combination of three different fertilizer levels and three drip irrigation levels at 40, 80 and 120 days after sowing are illustrated in Fig. 2. Plant height results after 40 days of sowing under drip fertigation combination treatments shows that maximum average plant height was obtained in F_2I_2 treatment (48.73 cm) followed by F_3I_2 (45.37 cm) treatment which were statistically at par with all other drip fertigation combination treatments , whereas minimum plant height was observed in F_1I_1 treatment (20.50 cm). Considering only the effect of fertilizer levels, F_3 treatment was the best followed by F_2 and F_1. F_3 treatment is significantly better than F_2 treatment, but both are significantly better than F_1 treatment. Also, considering irrigation levels only, I_2 was the best followed by I_3 and I_1. I_2 treatment was significantly better than I_3, but both were significantly better than I_1 treatment. Plant height under control treatment was 38.24 cm.

Plant height results after 80 days of sowing under drip fertigation combination treatments, showed that maximum average plant height was obtained in F_2I_2 treatment (98.07 cm) followed by F_3I_2 (95.03 cm) treatment which were statistically at par with all other drip fertigation combination treatments, whereas minimum plant height was observed in F_1I_1 treatment (59.17 cm). Considering only the effect of fertilizer levels, F_3 treatment was the best followed by F_2 and F_1. F_3 treatment is significantly better than F_2 treatment, but both are significantly better than F_1 treatment. Also, considering irrigation levels only, I_2 was the best followed by I_3 and I_1. I_2 treatment is statistically at par with I_3 treatment, but both are significantly better than I_1 treatment. Plant height under control treatment was 81.34 cm.

Plant height results after 120 days of sowing under drip fertigation combination treatments showed that maximum average plant height was obtained in F_2I_2 treatment (145.07 cm) followed by F_3I_2 (138.70 cm), F_3I_3 (138.50 cm) and F_2I_3 (138.03 cm) treatment which are statistically at par with each other but significantly better than all other drip fertigation combination treatments, whereas minimum plant height was observed in F_1I_1 treatment (95.70 cm). Considering only the effect of fertilizer levels, F_3 treatment was the best followed by F_2 and F_1. F_3 treatment is at par with F_2 treatment, but both are significantly better than F_1 treatment. Also, considering irrigation levels only, I_2 was the best followed by I_3 and I_1. I_2 treatment is statistically at par with I_3, but both are significantly better than I_1 treatment. Plant height under control treatment was 122.78 cm. The result showed the same trend as reported by [9],[7] and [10].

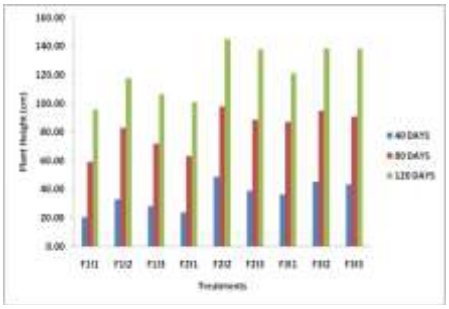

Fig. 2 Plant height under different treatments

3.1.3 Days to flowering

As illustrated in Fig. 3, under drip fertigation combination treatments, minimum days to first flowering was obtained in F_2I_2 treatment (39.97 days) followed by F_3I_2 (40.37 days) treatment which are statistically at par with all other treatments, whereas maximum days to first flowering was obtained in F_1I_1

treatment (47.13 days). Considering only the effect of fertilizer levels, all F_1, F_2 and F_3 treatments are statistically at par with each other. Also, considering irrigation levels only, all I_1, I_2 and I_3 treatments were statistically at par with each other. Average days to flowering under control treatment were 42.83 days. The results are in line with [11] and [12].

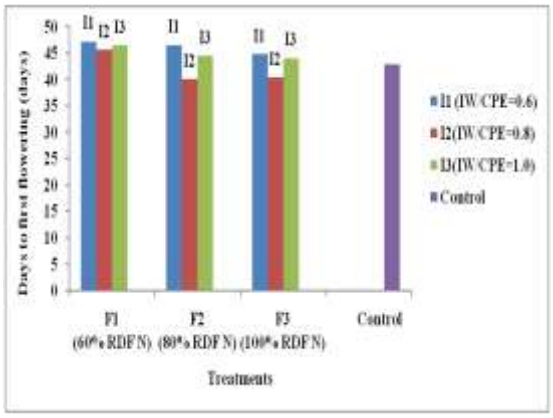

Fig. 3 Days to first flowering of okra crop under different treatments

3.1.4 Days to fruit initiation

As illustrated in Fig. 4, under drip fertigation combination treatments, minimum days to fruit initiation was obtained in F_3I_2 treatment (45.49 days) followed by F_2I_2 (46.09 days) which also recorded best yield treatment both are statistically at par with all other treatments, whereas maximum days to fruit initiation was observed in F_1I_1 treatment (52.93 days). Considering only the effect of fertilizer levels, all F_1, F_2 and F_3 treatments are statistically at par with each other. Also, considering irrigation levels only, all I_1, I_2 and I_3 treatments were statistically at par with each other. Days to fruit initiation under control treatment were 50.44 days. Results obtained for days to fruit initiation are in line with similar results reported by [11].

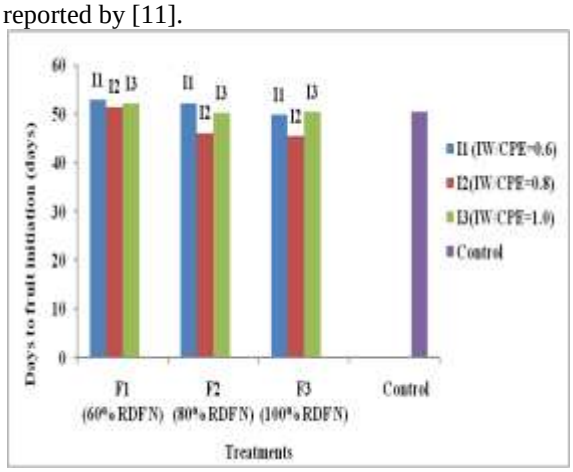

Fig. 4 Days to fruit initiation of okra crop under different treatments

3.1.5 Days to fruit maturity

As illustrated in Fig. 4.5, under drip fertigation combination treatments, minimum days to fruit maturity was obtained in F_3I_2 treatment (48.1 days) followed by F_2I_2 (48.2 days) which is also best yield treatment both are statistically at par with all other treatments, whereas maximum days to fruit maturity was obtained in F_1I_1 treatment (55.5 days). Considering only the effect of fertilizer levels, all F_1, F_2 and F_3 treatments were statistically at par with each other. Also, considering irrigation levels only, I_1, I_2 and I_3 treatments were statistically at par with each other. Days to fruit maturity under control treatment was 53.67 days. [11] reported similar results.

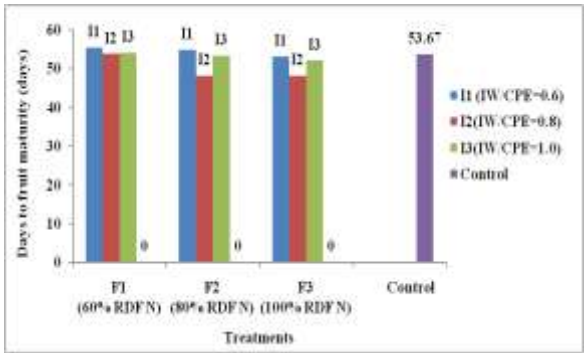

Fig. 5 Days to fruit maturity under different treatments

3.2 Yield and Yield Attributes

3.2.1 No. of Fruits per Plant

As illustrated in Fig. 6. Under drip fertigation combination treatments, maximum no. of fruits per plants were observed in F_2I_2 treatment (18.67) followed by F_3I_2 treatment (16.73) which are statistically at par with to all other drip fertigation combination treatments, whereas minimum plant population was obtained in F_1I_1 treatment (11.73). Considering only the effect of fertilizer levels, F_3 treatment was the best followed by F_2 and F_1. F_3 treatment is statistically at par with F_2 treatment, but both are significantly better than F_1 treatment. Also, considering irrigation levels only, I_2 was best followed by I_3 and I_1. I_2 treatment is statistically at par with I_3 but both are significantly better than I_1 treatments. No. of fruits per plants under control treatment was 13.21. Results obtained for fruit number per plant are in accordance with similar results reported by [13], [11], [5] and [14].

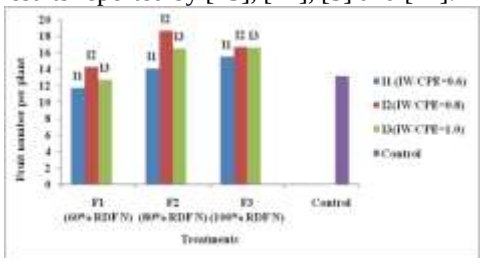

Fig. 6 Fruit number per plant under different

treatments

3.2.2 Fruit length

As illustrated in Fig. 7. Under drip fertigation combination treatments, maximum fruit length was obtained in F_2I_2 treatment (10.83 cm) followed by F_3I_2 treatment (10.77 cm) which are statistically at par with all other drip fertigation combination treatments, whereas minimum fruit length was obtained in F_1I_1 treatment (7.60 cm). Considering only the effect of fertilizer levels, F_3 treatment is statistically at par with F_2 treatment, but both are significantly better than F_1 treatment. Also, considering irrigation levels only, I_1, I_2 and I_3 treatments are statistically at par with each other. Fruit length under control treatment was 9.83 cm. [15] and [13] reported results on fruit lengths which are in line with results presented in Fig.7.

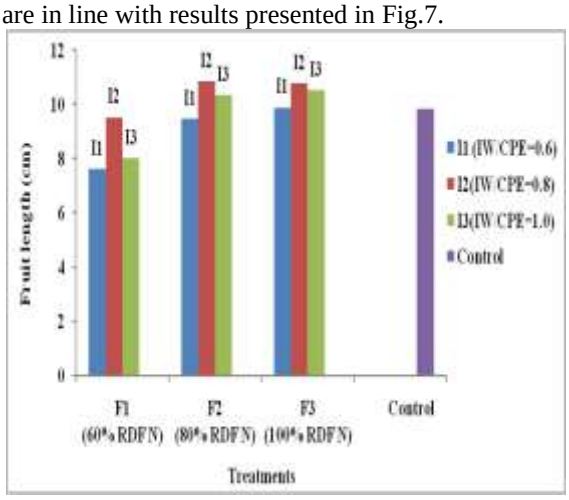

Fig. 7 Fruit length of okra crop under different treatments

3.2.3 Fruit weight

As illustrated in Fig. 8, under drip fertigation combination treatments, maximum fruit weight was obtained in F_2I_2 treatment (9.7 gm) followed by F_3I_2 (9.3 gm), but both are statistically at par with all other treatments, whereas minimum fruit weight was obtained in F_1I_1 treatment (8.5 gm). Considering only the effect of fertilizer levels, all F_1, F_2 and F_3 treatments are statistically at par with each other. Also, considering irrigation levels only, all I_1, I_2 and I_3 treatments are statistically at par with each other. Average fruit weight under control treatment was 8.2 gm. Results obtained were in accordance with similar results reported by [13], [14] and [15].

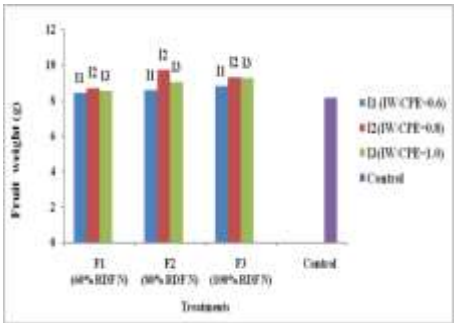

Fig. 8 Fruit weight of okra crop under different treatments

3.2.4 Fruit volume

As illustrated in Fig. 9, under drip fertigation combination treatments, maximum fruit volume was obtained in F_2I_2 treatment (19.77 cm^3) followed by F_3I_2 (19.5 cm^3) and F_3I_3 (19.5 cm^3), but both are statistically at par with all other treatments, whereas minimum fruit volume was obtained in F_1I_1 treatment (13.03 cm^3). Considering only the effect of fertilizer levels, F_1, F_2 and F_3 treatments are statistically at par with each other. Also, considering irrigation levels only, I_2 and I_3 treatments are statistically at par with each other but both are significantly better than I_1. Average fruit volume under control treatment was 14.7 cm^3. [8] reported results on okra volume which is in similar trend as that of results shown in Fig.9.

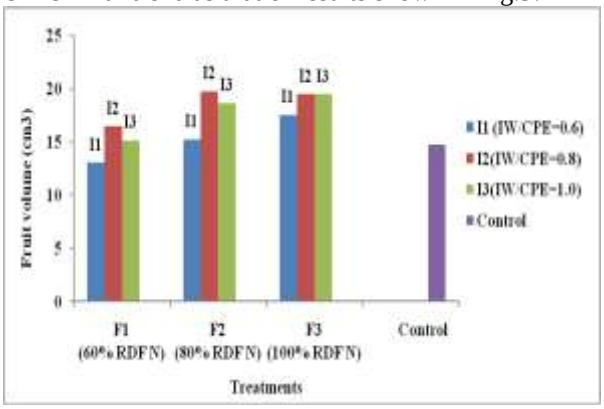

Fig. 9 Fruit volume under different treatments

3.2.5 Okra yield

Okra yield results obtained in the experiment are presented in Table. 1 along with statistical analysis results. Considering only the effect of fertilizer levels, F_3 (14.38t/ha) treatment was the best followed by F_2 (14.12 t/ha) and F_1 (11.72 t/ha). F_2 treatment is statistically at par with F_3 treatment, but both are significantly better than F_1 treatment. Also, considering irrigation levels only, I_2 (14.57 t/ha) was the best followed by I_3 (13.79 t/ha) and I_1 (11.87 t/ha). I_2 treatment is statistically at par with I_3 treatment, but significantly better than I_1 treatment. Maximum average okra yield was obtained in F_2I_2 treatment followed by F_3I_2 treatment which is statistically at par with each other but superior to all

other treatment, whereas minimum okra yield was obtained in F_1I_1 treatment. Split application of nutrients by drip fertigation as compared to traditional furrow method may have resulted in reduced nutrient wastage and hence, leading to better yield in drip fertigation method. Regular and often use of drip irrigation results in maintaining moisture conditions in the crop root zone leading to higher water as well as nutrient availability to the plant [16]. It is clear from the results of the statistical analysis (Table 4.10) that the effect of different levels of fertigation and their combination has significant effect on okra yield [17].

Table 1 Okra yield under different irrigation and fertilizers level treatments

Okra Yield (t/ha)				
Fertilizer Treatments	**Drip irrigation treatments**			
	I_1	I_2	I_3	**Mean**
F_1	10.68	12.44	12.03	**11.72**
F_2	12.16	15.89	14.32	**14.12**
F_3	12.75	15.38	15.02	**14.38**
Mean	**11.87**	**14.57**	**13.79**	
CD (5%)	**F=0.501**	**I=0.466**	**FI=0.808**	
Control				**11.4**

IV. CONCLUSIONS:

Plant population and Plant height after 40, 80 and 120 days of sowing was maximum at 80% fertilizer N dose and 80% irrigation treatment. Days to first flowering were minimum in at 80% fertilizer N dose and 80% irrigation treatment. Days to fruit initiation and Days to fruit maturity were minimum at 100% fertilizer N dose and 80% irrigation . Fruit number per plant, Fruit length and Fruit volume were observed to be maximum at 80% fertilizer N dose and 80% irrigation treatment. While, there was non-significant effect of irrigation and fertigation combination treatments on plant population, plant height, days to flowering, days to fruit initiation, days to fruit maturity, fruit number per plant, fruit length and fruit volume. Okra yield was maximum in at 80% fertilizer N dose and 80% irrigation level (15.89 t/ha) and minimum in F_1I_1 treatment (10.68 t/ha). There was significant effect of irrigation, fertilizer and combination on okra yield.

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