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Effect of irrigation methods and fertigation on summer okra (*Abelmoschus esculentus* (L.) Moench)

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Abstract
An experiment entitled "Effect of irrigation methods and fertigation on summer okra (*Abelmoschus esculentus* (L.) Moench)" was conducted at Vegetable Research Station, Junagadh Agricultural University, Junagadh (Gujarat) during summer season of 2019. The experiment was laid out in split plot design with three replications. The results showed that drip fertigation at 0.8 PEF with plastic much and application of 100% RDF in six equal splits at 10 days interval in summer okra gave superior plant height, number of branches per plant, number of inter node per plant, number of fruits per plant, length of fruit, girth of fruit, weight of five fruits, fruit yield per plant and fruit yield can be obtained on medium black calcareous soil.

Keywords: Okra, drip irrigation, drip fertigation, mulching, nitrogen, split, WUE

Introduction
Okra (*Abelmoschus esculentus* (L.) Moench) was earlier included in section *Hibiscus*, genus *Abelmoschus* and the family Malvaceae. It is known as a 'Gumbo' in United States of America, 'lady's finger' in England and 'Bhindi' in India. It is one of the most important fruit vegetables grown throughout the tropics and warmer parts of the temperate zone. Okra is native to South Africa and Asia. It is an herbaceous hairy annual vegetable crop of tropical and subtropical parts of the world. It is one of the most important nutritious vegetable crops grown round of the year in India during *kharif* and summer seasons. Okra is mainly propagated by seeds and has duration of around 90 to 100 days. It is widely cultivated in all over India for its immature tender fruit which is used as vegetable in variety of ways. Green revolution is one of the greatest successes that the country has achieved. However, even after attaining self-sufficiency in the food grains, India still faces the challenge of malnutrition. Lower intake of vegetables being one of the major factor of malnutrition for a balanced diet, as per the recommendation of World Health Organization.

Drip irrigation is a regulated and slow application of irrigation water through emitters at frequent intervals near the plant root zone over a long period of time. Adoption of drip irrigation helps to reduce the over exploitation of ground water. Mulching with drip irrigation system is an effective method to manipulate crop growing environment to increase yield and improve product quality by ameliorating soil temperature, conserving soil moisture, reducing soil erosion, weed control, improving soil structure and enhancing root system development by optimizing the level of nitrogen and carbon dioxide. In the use of silver black plastic mulch, the silver side must be laid upward to reflect the sunlight for pests prevent and the black side lay downward to block sunlight for weed control.

Materials and Methods
The experiment entitled "Effect of irrigation methods and fertigation on summer okra (*Abelmoschus esculentus* (L.) Moench)" was conducted during summer season of year 2019 at Vegetable Research Station, Junagadh Agricultural University, Junagadh. Geographically, Junagadh is situated at 21.5º N latitude and 70.5º E longitude with an altitude of 60 m above mean sea level. The experimental plot was clayey in texture and slightly alkaline in reaction. The soil was medium in available nitrogen (260 kg/ha), phosphorus (37 kg/ha) and potassium (240 kg/ha) during summer season 2019.

The mean maximum and minimum temperature during the crop growth and development period ranged between 29.2 ℃ to 42.2 ℃ and 12.1 ℃ to 27.4 ℃.

Summer season remain hot particularly during fourth week of April to fourth week of May with maximum temperature below 42.2 ℃ and minimum temperature above 21.6 ℃. The maximum relative humidity was below 82% and minimum was above 21%. The range of wind speed and daily pan evaporation were 4.0 to 9.5 km/h and 5.5 to 11.7 mm, respectively. The experiment comprising of four levels of irrigation methods (Surface irrigation at 1.0 IW: CPE, Drip irrigation at 0.8 PEF, Drip fertigation at 0.8 PEF and Drip fertigation at 0.8 PEF and plastic mulch) and two levels of nitrogen (75% of RDF i.e. 112.5 and 100% of RDF i.e. 150 kg/ha) were laid out in split plot design with three replications. The okra variety 'Gujarat Okra – 6' was sown at 45 x 15 cm paired rows. The crop was fertilized with 150-50-00 kg/ha N-P_2O_5-K_2O. The crop was raised as per the recommended package of practices.

Results and Discussion

Effect of irrigation methods and drip fertigation

The results revealed that drip fertigation at 0.8 PEF and plastic mulch (I_4) had favourable effect on growth and yield of okra over surface irrigation at 1.0 IW: CPE (I_1). All the growth and yield parameters *viz.* plant height at harvest, number of branches per plant at harvest, number of internodes per plant at harvest, days taken to first picking of okra fruit, number of green fruits per plant, length of fruit, girth of fruit, weight of five fruits, fruit yield per plant and green fruit yield were significantly influenced by drip fertigation with mulching but remained at par with drip fertigation at 0.8 pan evaporation fraction.

It is well established fact that where sufficient soil moisture for continued growth is maintained by providing drip irrigation which leads to greater development of green tissue area results in higher photosynthetic assimilation as a result improve the plant growth. This leads to increase in accumulation of carbohydrates and metabolites which ultimately determine the length and girth of fruit. The increased in all these growth and yield attributes might be due to adequate supply of water and nutrients at proper time and conserving moisture in root regimes through mulching. Irrigation water used for growing the crop needs to be managed on two fronts like firstly, the method of application and secondly the conservation in field after application. So, drip fertigation is the most effective way of application of water and nutrients to the root zone and mulching is the best way for conservation of moisture in the soil after application. The results of present investigation are in line with those of Laxmikanth *et al.* (2018) [7], Shelke *et al.* (2019) [13] and Sreeja and Satasiya (2020) [15] in respect of drip fertigation with mulching and those of Pandey *et al.* (2013) [9] and Hari and Ramesh (2017) [6] in respect of application of fertilizer through drip fertigation than manual application of fertilizer. The results also agreement with findings reported by Pandey *et al.* (2013) [9], Challa *et al.* (2017) [4] and Gireesh (2017) [5], in respect of application of water through drip irrigation over than surface irrigation.

Effect of nitrogen levels

Growth parameters *viz.*, plant height at harvest, number of branches per plant at harvest, number of internodes per plant and days taken to first picking of okra fruit and the data on yield attributing characters *viz.*, number of green fruits per plant, length of fruit, girth of fruit, weight of five fruits, fruit yield per plant and green fruit yield were significantly influenced by nitrogen levels. Application of 100% recommended dose of nitrogen *i.e.* 150 kg/ha N recorded significantly the highest values for growth and yield parameters. Significantly the lowest values for these growth and yield attributes were recorded under application of 75% recommended dose of nitrogen *i.e.* 112.5 kg/ha N.

The improvement in growth and yield parameters with application of 100% recommended dose of nitrogen *i.e.* 150 kg N ha^{-1} might have resulted in adequately, better and timely availability of N for their utilization by plant as judged from nitrogen content in fruit.

Under the present investigation, profound influence of N a component of fertility management, on crop growth and yield seem to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from soil media. The significant improvement in nutrient status of plant parts (fruit) might have resulted in greater synthesis of amino acid, proteins and growth promoting substances, which seems to have enhanced meristematic activity and increased cell division and their elongation. Application of 100% recommended dose of nitrogen *i.e.* 150 kg/ha N has increased interception, absorption and utilization of radiant energy which in turn increased photosynthesis and there by different growth and yield parameters The present findings are within the close vicinity of those reported by Raval *et al*. (2013) [10], Singh and Singh (2016) [14], Adlan *et al*. (2017) [2], Nair *et al*. (2017) [8], Reddy *et al*. (2018) [11] and Sahebrao (2019) [12].

Interaction effect

The interaction effect of irrigation methods, fertigation and nitrogen level was found to be significant on green fruit yield per plant, green fruit yield kg/ha.

The interaction effect of drip fertigation at 0.8 PEF and plastic mulch along with 100% recommended dose of nitrogen *i.e.* 150 kg/ha N (I_4N_2) registered maximum green fruit yield per plant and green fruit yield kg/ha as compared to drip irrigation without fertigation and mulching with nitrogen level treatments. The maximum yield under the treatment combination I_4N_2 might be due to the fact that sufficient soil moisture along with N application under drip fertigation with mulching leads to better development of photosynthetic area and accelerated photosynthetic rate, cell turgidity, cell and tissue growth accompanied with better nutritional environment in the root zone. Similar findings were observed by Abhiman (2017) [1], Bhutia *et al*. (2017) [3] and Shelke *et al*. (2019) [13].

Table 1: Effect of irrigation methods, fertigation and nitrogen levels on growth attributes of summer okra.

Treatments	Plant height at harvest (cm)	Number of branches per plant	Number of inter nodes per plant	Days taken to first picking of fruit
Irrigation levels (I)				
I_1: Surface irrigation at 1.0 IW: CPE	66.61	2.93	15.75	52.37
I_2: Drip irrigation at 0.8 PEF	78.69	3.47	17.02	48.33
I_3: Drip fertigation at 0.8 PEF	90.64	4.20	18.17	46.03
I_4: Drip fertigation at 0.8 PEF and plastic mulch	98.85	4.70	19.33	44.50
S.Em.±	2.46	0.15	0.68	1.35
C.D. at 5%	8.53	0.53	2.34	4.68
C.V. %	7.21	9.86	9.42	6.91
Nitrogen levels (N)				
N_1: 75% RDF	79.63	3.63	17.21	47.17
N_2: 100% RDF	87.76	4.02	17.93	48.60
S.Em.±	0.79	0.06	0.21	0.42
C.D. at 5%	2.58	0.19	0.69	1.37
C.V. %	3.27	5.15	4.14	3.04
Interaction I x N				
S.Em.±	1.58	0.11	0.42	0.84
C. D. at 5%	NS	NS	NS	NS

Table 2: Effect of irrigation methods, fertigation and nitrogen levels on yield and yield attributes of summer okra.

Treatments	Number of green fruits per plant	Length of fruit (cm)	Girth of fruit (cm)	Weight of five fruits (g)	Green fruit yield per plant (g)	Green fruit yield (t/ha)
Irrigation levels (I)						
I_1: Surface irrigation at 1.0 IW: CPE	14.75	11.08	3.24	65.42	191.25	10.42
I_2: Drip irrigation at 0.8 PEF	18.02	12.17	4.45	70.08	272.28	14.83
I_3: Drip fertigation at 0.8 PEF	22.17	13.57	4.67	75.67	362.38	19.74
I_4: Drip fertigation at 0.8 PEF and plastic mulch	26.33	14.16	4.98	81.58	396.67	21.61
S.Em.±	0.68	0.38	0.14	2.79	11.49	0.63
C.D. at 5%	2.34	1.30	0.50	9.66	39.76	2.17
C.V. %	7.95	7.23	8.10	9.34	9.21	9.21
Nitrogen levels (N)						
N_1: 75% RDF	20.46	12.43	4.28	71.38	293.82	16.00
N_2: 100% RDF	21.18	13.06	4.38	75.00	317.48	17.29
S.Em.±	0.21	0.19	0.03	1.10	3.57	0.20
C.D. at 5%	0.69	0.63	0.08	3.57	11.65	0.64
C.V. %	3.50	5.25	2.00	5.19	4.05	4.05
Interaction I x N						
S.Em.±	0.42	0.39	0.05	2.19	7.15	0.39
C. D. at 5%	NS	NS	NS	NS	23.30	1.27

Conclusion

On the basis of the results obtained from the one year study, it could be concluded that drip fertigation at 0.8 PEF with plastic mulch and application of 100% recommended dose of nitrogen i.e. 150 kg/ha in six equal splits at 10 days interval in summer okra, the higher green fruit yield can be obtained on medium black calcareous soil of South Saurashtra Agro-climatic Zone.

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