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Effect of fertigation on growth, quality and yield of Brinjal

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Abstract
A field experiment was undertaken during rabi season of 2017-18 at research farm of Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to investigate the effect of fertigation on growth, dry matter and quality of brinjal. The experimental design was randomized block design with five treatments replicated four times. The study revealed that yield, plant height, number of branches per plant, number of leaves, number of fruits per plant, average weight of fruit, yield of fruits per plant, leaf dry matter, fruit dry matter and total dry matter was improved with increased fertigation level as compared to traditional application of fertilizer. All the growth parameters were found significantly highest in treatment having drip fertigation at 150% RDF and were found at par with treatment having drip fertigation at 125% RDF.

Keywords: Fertigation, Brinjal, RDF, Drainage Engineering

Introduction
Brinjal (*Solanum melongena* L.) is one of the most common vegetables grown throughout the country for its purple, green or white pendulous fruit. It is a member of the Solanaceae family. Brinjal is a hardy crop and is cultivated under a wide range of soils. Fertigation is an agricultural technology that combines irrigation and fertilization. Fertigation technology uses a pressure system (or a height difference in the terrain) to combine soluble solid or liquid fertilizers with irrigation water, according to the soil nutrient content and the nutritional needs of the crop, and through the help of a controllable pipeline system. Fertigation can be used to avoid problems such as volatilization losses, slow dissolution, and slow fertilizer activation that arise from applying fertilizer onto dryer surface soils. Plastic mulching film has become an important agriculture production material. Plastic film mulching has markedly improved crop yields and water use efficiency through maintaining soil moisture, suppressing weeds and, increasing soil temperature.

Material and Methods
A field experiment was carried out during *Rabi* season of 2017-18 at research farm of Department of Irrigation and Drainage Engineering, Dr. P.D.K.V., Akola. The soil of the experimental site was low in available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in randomized block design with five treatments (T_1 – 75% RDF, T_2 – 100% RDF, T_3 – 125% RDF, T_4 – 150% RDF all through drip fertigation and T_5 – 100% RDF with traditional application of fertilizers) replicated four times. Firstly for land preparation, harrowing was done once by means of tractor. The ridges were formed at 90 cm spacing with approximately height of 30 cm. Accordingly, the layout was prepared and the pipeline for irrigation was installed. The water was conveyed to inline drip through the pipe lines installed at the experimental site. The irrigation system mainly consists of mainline, sub mainline, inline lateral, screen filter, fertigation tank, accessories such as control valve, tee, reducer, elbow, coupling, G.T.O (Gromet Take Off) etc. A silver-black polyethylene mulch of 50 µm thickness (UV – protected) was spread over the raised ridge after installing the drip system keeping silver colour upside. The recommended fertilizer dose of 150:75:75 N:P:K kg ha^{-1} was used. For growth studies five plants in the net plot from each replication were selected at random and labelled for recording of various observations. The plant height was measured at 30 days interval of the five randomly selected observation plants. The height of the main shoot was measured in cm from the ground level. The actual number of branches arising from the main stem of all the observation plants were noted down at 30 days interval. The number of leaves per plant were counted manually from the five randomly selected observation plants in each replication of the treatment plot at 30, 60, 90 days after

transplanting and at harvest and their averages were calculated. Number of fruits harvested from observation plants at every picking was taken into consideration to work out mean number of fruits per plant. Weight of harvested brinjal for each observation plant was taken at every picking and total weight of brinjal harvested from each plant throughout the season was observed. Thus, yield of fruit per plant throughout the season was obtained treatment wise. Length of the fruit was measured with the help of vernier calliper and expressed in centimeters and mean values of 5 fruits per treatment per replication was used for analysis. The individual fruit weight was recorded by weighing 5 randomly selected fruits from sample plants in each treatment and averages were worked out and expressed in grams. The yield of brinjal from net plot in every treatment was observed in every picking. The total yield of the fruit harvested from net plot was recorded by cumulating yield per picking and expressed in kg per plot and then it is converted into quintal per hectare. Total soluble solids (TSS) in fruits was determined by hand held refractometer. Dry matter content per plant was recorded at harvest. The selected plants for this purpose was pulled out carefully and sun dried for two days followed by oven drying at 60 °C till a constant weight was obtained and the weights were read for recording dry matter. Similarly fruit samples were also sun dried and oven dried and dry matter yield was calculated. Total cost comprised of fixed cost plus operating cost. Total cost per ha was calculated for comparison on per hectare basis. Gross return is worked out by considering the yield of produce and its selling price. Net return is calculated by subtracting cost of production from gross return in each treatment. Net return is calculated by subtracting cost of production from gross return in each treatment. Benefit cost ratio was estimated by using following formula.

$$\text{Benefit cost ratio} = \frac{\text{Gross return per season}}{\text{Total cost per season}}$$

Results and Discussion

Plant height

The data regarding plant height was recorded and presented in Table 1. The plant height of brinjal increased with increase in period from transplanting in all treatments and highest plant height was recorded at harvest. It is seen from the observations that during initial growth stages (30 and 60 DAT) of brinjal crop, the maximum plant height was found in control treatment T_5 i.e. in traditional soil application of fertilizer with 100% recommended dose of fertilizer (RDF). This high growth of plant in treatment T_5 may be due to that whole fertilizer dose was given during initial growth stage of crop i.e. before 60 DAT. However at 90, 120 DAT and at harvest significantly highest plant height was observed in treatment T_4 (Drip fertigation at 150% RDF) and was found to be at par with treatment T_3 (Drip fertigation at 125% RDF) followed by treatment T_2 (Drip fertigation at 100% RDF) and T_1 (Drip fertigation at 75% RDF). Lowest plant height was observed in treatment T_5 (Traditional fertilization at 100% RDF) and it was found at par with treatment T_1 (Drip fertigation at 75% RDF) at 90, 120 DAT, and at harvest. Nitrogen plays role in cell elongation and cell division. So, Increment in plant height in drip fertigation treatment was observed may be because of increased nitrogen availability through drip as compared to traditional fertilizer application. Similar findings were recorded by Solimani and Byari (4) and Sollapur and Hiremath (5) who found that in eggplant as nitrogen fertilizer increased plant height significantly and that higher fertilizer levels recorded significantly maximum plant height in hybrid brinjal.

Table 1: Plant height of brinjal as influenced by different levels and methods of fertilizer application

Treatments	Plant height (cm)				
	30 DAT	60 DAT	90 DAT	120 DAT	At Harvest
T_1 (Drip fertigation at 75% RDF)	10.83	32.49	68.65	71.77	73.06
T_2 (Drip fertigation at 100% RDF)	11.35	35.00	79.57	80.65	82.48
T_3 (Drip fertigation at 125% RDF)	12.43	39.10	88.11	89.64	91.64
T_4 (Drip fertigation at 150% RDF)	13.03	39.58	89.84	90.42	92.07
T_5 (Traditional fertilization at 100% RDF)	13.75	41.34	68.21	71.17	72.60
SE (m) ±	0.74	1.40	2.65	2.82	2.97
CD at 5%	2.28	4.31	8.17	8.68	9.15

Number of branches per plant

The data pertaining to average number of branches per plant as influenced by drip fertigation with different fertilizer levels and traditional method of fertilizer application is presented in Table 2. The number of branches per plant of brinjal increased with increase in period and higher number of branches were recorded at harvesting stage. It is observed from the observations that during initial growth stages (30 and 60 DAT) of brinjal crop the differences in number of branches per plant were non-significant and was found to be maximum in control treatment, T_5 (Traditional fertilization at 100% RDF). Numerically highest number of branches per plant were observed in control treatment T_5 may be due to that in treatment T_5 full dose of fertilizer was applied within 60 DAT. At 90 DAT, significantly highest number of branches per plant were observed in treatment T_4 (Drip fertigation at 150% RDF) and it was found to be at par with treatments T_2 (Drip fertigation at 100% RDF) and T_3 (Drip fertigation at 125% RDF).

Table 2: Number of branches per plant of brinjal as influenced by different levels and methods of fertilizer application

Treatments	Number of branches per plant				
	30 DAT	60 DAT	90 DAT	120 DAT	At Harvest
T_1 (Drip fertigation at 75% RDF)	4.45	10.60	13.25	15.05	15.90
T_2 (Drip fertigation at 100% RDF)	4.47	11.90	15.65	17.43	18.25
T_3 (Drip fertigation at 125% RDF)	5.00	12.25	17.05	20.33	21.10
T_4 (Drip fertigation at 150% RDF)	5.11	12.60	17.15	20.90	21.50
T_5 (Traditional fertilization at 100% RDF)	5.50	12.90	13.10	14.23	14.95
SE (m) ±	-	-	0.72	0.74	0.72
CD at 5%	-	-	2.23	2.27	2.21

The lowest number of branches per plant were observed in treatment T_5 (Traditional fertilization at 100% RDF) and it was found to be at par with treatment T_1 (Drip fertigation at 75% RDF) at 90 DAT. Similarly, treatment T_2 was found to be at par with T_3 and T_4. At 120 DAT and at harvest, treatment T_4 (Drip fertigation at 150% RDF) showed significantly highest number of branches per plant over other treatments. However, it was at par with treatment T_3. Whereas lowest number of branches per plant was observed in treatment T_5 (Traditional fertilization at 100% RDF) and was found at par with treatment T_1. Due to application of 100 per cent fertilizer by traditional method at the time of

transplanting (30 and 45 DAT) the initial growth was increased so during initial days the number of branches were more in treatment T_5 (Traditional fertilization at 100% RDF) and after 60 DAT the growth of plant was retarded, whereas when fertilizers applied through drip, nutrients are directly applied to the root zone and fully utilized by plants, hence at 90 DAT, 120 DAT and at harvest the number of branches was more as compared to traditional method of fertilization. The results are in conformity with the findings of Sollapur and Hiremath (5) who reported that higher fertilizer levels recorded significantly higher number of branches per plant in hybrid brinjal.

Number of leaves

The data regarding number of leaves per plant was recorded and presented in Table 3. It was observed that initially at 30 and 60 DAT of brinjal crop, significantly highest number of leaves per plant was found in treatment T_5 (Traditional fertilization at 100% RDF). Whereas, treatment T_2 (Drip fertigation at 100% RDF), T_3 (Drip fertigation at 125% RDF), and T_4 (Drip fertigation at 150% RDF) were found at par. At 90 DAT and at harvest, significantly highest number of leaves per plant was observed in treatment T_4 (Drip fertigation at 150% RDF) and it was found to be at par with treatment T_3 (Drip fertigation at 125% RDF). However lowest number of leaves per plant was recorded in treatment T_5 (Traditional fertilization at 100% RDF). It indicates that drip fertigation treatments showed improvement in number of leaves per plant as compared to application of fertilizers conventionally. Due to application of water soluble fertilizer through drip directly in root zone helped in increasing vegetative growth. Similar findings were recorded by Sollapur and Hiremath (5) who found that higher fertilizer levels recorded significantly higher number of leaves per plant in hybrid brinjal.

Table 3: Number of leaves per plant of brinjal as influenced by different levels and methods of fertilizer application

Treatments	Number of leaves			
	30 DAT	60 DAT	90 DAT	At Harvest
T_1 - Drip fertigation at 75% RDF)	32.10	55.51	79.31	80.49
T_2 - Drip fertigation at 100% RDF	32.75	58.50	81.00	82.10
T_3 - Drip fertigation at 125% RDF	34.89	59.29	82.68	85.34
T_4 - Drip fertigation at 150% RDF	35.50	61.50	85.1	86.50
T_5 - Traditional fertilization at 100% RDF	38.79	65.91	77.00	78.25
SE (m) ±	0.96	1.30	1.22	1.35
CD at 5%	2.96	4.00	3.76	4.17

Number of fruits per plant

The data on number of fruits harvested per plant as influenced by drip fertigation with different fertilizer levels and traditional method of fertilizer application is presented in Table 4. The results revealed that there was increase in number of fruits per plant as the fertigation levels increased. Treatment T_4 (Drip fertigation at 100% RDF) showed significantly highest number of fruits per plant (98.60) over treatments T_1, T_2 and T_5. However, it was found at par with treatment T_3 (Drip fertigation at 125% RDF). Lowest number of fruits per plant (70.78) was recorded in treatment T_5 (Traditional fertilization at 100% RDF). The higher number of fruits were observed in drip fertigation treatments as compared to traditional method of fertilizer application with solid fertilizer may be due to frequent and required application of nutrients along with irrigation water within effective root zone of crop thereby, increasing the availability of nutrients in soil which has increased the number of fruits in fertigation treatments. The results are in conformity with the findings of Badr *et al.* (2) and Ughade and Mahadkar (6). Badr *et al.* (2) conducted an experiment with eggplant and phosphorus fertigation rate and found that number of fruits per plant increases with increasing phosphorus level. Ughade and Mahadkar (6) conducted an experiment and found that different levels of fertigation recorded significantly higher number of fruits per plant in brinjal.

Table 4: Number of fruits per plant as influenced by different levels and methods of fertilizer application

Treatments	Number of fruits per plant
T_1 (Drip fertigation at 75% RDF)	71.85
T_2 (Drip fertigation at 100% RDF)	85.15
T_3 (Drip fertigation at 125% RDF)	98.35
T_4 (Drip fertigation at 150% RDF)	98.60
T_5 (Traditional fertilization at 100% RDF)	70.78
SE (m) ±	4.27
CD at 5%	13.16

Average length of brinjal fruit

The data on average length of brinjal fruit as influenced by drip fertigation with different fertilizer levels and traditional method of fertilizer application is presented in Table 5. The data on average length of fruit was found to be non-significant.

Table 5: Average length and average weight per fruit as influenced by different levels and methods of fertilizer application

Treatments	Average length of brinjal (cm)	Average weight per fruit (g)
T_1 - Drip fertigation at 75% RDF	7.83	68.83
T_2 - Drip fertigation at 100% RDF	7.93	72.00
T_3 - Drip fertigation at 125% RDF	8.05	73.66
T_4 - Drip fertigation at 150% RDF	8.28	75.31
T_5 - Traditional fertilization at 100% RDF	7.70	66.56
SE (m) ±	-	0.87
CD at 5%	-	2.69

Average weight per fruit

The data of average weight per fruit is presented in Table 5. The results revealed that there was increase in average weight per fruit as the fertigation level increased. The significantly highest average weight per fruit was observed in treatment T_4 (Drip fertigation at 150% RDF) over treatments T_1 (Drip fertigation at 75% RDF), T_2 (Drip fertigation at 100% RDF), and T_5 (Traditional fertilization at 100% RDF). However, it was found to be at par with treatment T_3 (Drip fertigation at 125% RDF). Lowest average weight per fruit was recorded in treatment T_5 (Traditional fertilization at 100% RDF). Weight of fruit increases with increasing nitrogen levels because weight of fruit depends upon the vegetative growth of plant. It was found that, optimum nitrogen levels leads to increased leaf growth ultimately which were capable of manufacturing the greater amount of food material and then the same translocated into fruit, leads to an increase in fruit weight. Similar findings were reported by Badr *et al.* (2) and Ughade and Mahadkar (6).

Yield of fruits per plant

The data pertaining to yield of fruits harvested per plant as influenced by different levels and methods of fertilizer application is presented in Table 6. The results revealed that

there was increase in yield of fruits per plant as the fertigation level increased. Significantly highest yield of fruits per plant (4698.21 g) was observed in treatment T_4 (Drip fertigation at 150% RDF). However, it was found to be at par with treatment T_3 i.e., Drip fertigation at 125% RDF (4639.19 g). Lowest yield of fruits per plant (3375.64 g) was recorded in treatment T_5 (Traditional fertilization at 100% RDF). The highest yield of fruits per plant were observed in drip fertigation treatments as compared to traditional method of fertilizer application with solid fertilizers, may be due to frequent and application of nutrients through drip system which may causes higher uptake of nutrients by plants. Also the effects on growth components were highly pronounced with an increase in the levels of nitrogen resulting in translocation of sufficient food material for fruit development. Similar findings were reported by Badr *et al.* (2) and Ughade and Mahadkar (6).

Table 6: Yield of fruits per plant as influenced by different levels and methods of fertilizer application

Treatment	Yield per plant (g)
T_1 - Drip fertigation at 75% RDF	3576.27
T_2 - Drip fertigation at 100% RDF	4023.98
T_3 - Drip fertigation at 125% RDF	4639.19
T_4 - Drip fertigation at 150% RDF	4698.21
T_5 - Traditional fertilization at 100% RDF	3375.64
SE (m) ±	139.465
CD at 5%	429.707

Yield of brinjal

As the brinjal crop is vegetable crop, its harvesting was done from time to time by picking of fruits. The complete harvesting was obtained by 20 pickings. The data pertaining to average yield of brinjal as influenced by drip fertigation with different fertilizer levels and traditional method of fertilizer application is presented in Table 7. The yield of brinjal was influenced significantly due to different fertigation levels. Treatment T_4 (Drip fertigation at 150% RDF) recorded significantly highest yield of brinjal (557.10 q ha^{-1}) and it was found at par with treatments T_3 (Drip fertigation at 125% RDF), which was followed by treatments T_2 and T_1. The brinjal yield obtained under treatment T_2 (Drip fertigation at 100% RDF) was 499.67 q ha^{-1}, which was higher than the treatment T_1 (Drip fertigation at 75% RDF, 443.94 q ha^{-1}) and T_5 (Traditional fertilization at 100% RDF, 428.56 q ha^{-1}). Lowest yield of brinjal (428.56 q ha^{-1}) was observed in treatment T_5 (Traditional fertilization at 100% RDF), which may be due to less availability of nutrients at flowering and fruiting stage of crop, as whole fertilizer dose was given in vegetative growth stage itself in this treatment. It was seen that yield of brinjal in treatment T_4 was found to be higher than that of treatment T_3, which was statistically at par. But the advantage in treatment T_3 was requirement of 25% less amount of fertilizer. The higher yields in drip fertigation treatments may be due to regular availability of nutrients to plants by frequent application of nutrients at ten days interval; avoiding leaching of soluble fertilizers applied with measured and required amount irrigation water. Whereas, in traditional fertilization treatment, yield level may be low due to application of 50% N, 100% P and 100% K nutrients at the time of transplanting and remaining 50% N at 30 and 45 DAT; which may result in leaching of nutrients in later stages, which may affected the availability of nutrients at flowering and fruiting stage of crop. The results are in conformity with the findings of Ughade and Mahadkar (4) and Xiukang *et al.* (7). Ughade and Mahadkar (4) conducted an experiment and found that between different levels of fertigation the higher fertigation level recorded significantly higher yield of brinjal.

Table 7: Yield of brinjal as influenced by different levels and methods of fertilizer application

Treatments	Yield (q ha^{-1})
T_1 (Drip fertigation at 75% RDF)	443.94
T_2 (Drip fertigation at 100% RDF)	499.67
T_3 (Drip fertigation at 125% RDF)	554.88
T_4 (Drip fertigation at 150% RDF)	557.10
T_5 (Traditional fertilization at 100% RDF)	428.56
SE (m) ±	17.78
CD at 5%	54.78

Quality Parameter: TSS (Total soluble solids) of brinjal

The data regarding TSS of brinjal fruit is presented in Table 8. The results revealed that there was increase in TSS of fruit as the fertigation level increased. The data on TSS of fruit was found to be significant. Significantly highest TSS of fruit (7.50) was observed in treatment T_4 (Drip fertigation at 150% RDF) and it was found to be at par with treatment T_3 i.e., Drip fertigation at 125% RDF (7.33). Lowest TSS of fruit (6.60) was recorded in treatment T_5 (Traditional fertilization at 100% RDF). The highest fruit quality is might be due to nitrogen stimulates the functioning of enzymes in the physiological processes, which have improved the total soluble solids content of the fruits. Similar findings were observed by Solimani and Byari (4) and Mahadevan *et al.* (3).

Table 8: TSS of brinjal as influenced by different levels and methods of fertilizer application

Treatments	TSS (°Brix)
T_1 - Drip fertigation at 75% RDF	6.83
T_2 - Drip fertigation at 100% RDF	6.88
T_3 - Drip fertigation at 125% RDF	7.33
T_4 - Drip fertigation at 150% RDF	7.50
T_5 - Traditional fertilization at 100% RDF	6.60
SE (m) ±	0.20
CD at 5%	0.61

Dry matter

It is evident from the data in Table 9 that the significantly highest leaf dry matter, fruit dry matter and total dry matter were observed with treatment T_4 (Drip fertigation at 150% RDF) and were found to be at par with treatment T_3 (Drip fertigation at 125% RDF). While, the lowest leaf dry matter, fruit dry matter and total dry matter was recorded with treatment T_5 (Traditional fertilization at 100% RDF). More number of leaves per plant along with higher nutrient availability in soil would have contributed to accumulation of higher dry matter production. Nitrogen being a chief constituent of protoplasm might increase the synthesis of carbohydrates in leaves which might have added to the dry matter production. Similar results were reported by Aminifard *et al*. (1), Ugade and Mahadkar (6) and Xiukang *et al*. (7). Aminifard *et al*. (1) found that leaf dry matter increases with increasing fertigation rate. Ugade and Mahadkar (6) found that fruit dry matter, leaf dry matter, stem dry matter and total biomass of brinjal plant was high with higher rate of fertigation.

Benefit Cost ratio

As presented in Table 10 cost economics of the study shows that the highest net monetary returns was obtained in treatment T_3 i.e. fertigation with 125% RDF (267653 Rs ha^{-1}) followed by treatment T_4 i.e. fertigation with 150% RDF (261580 Rs ha^{-1}). Highest B:C ratio was obtained in treatment T_3 i.e. fertigation with 125% RDF (3.22) followed by treatments T_2 i.e. fertigation with 100% RDF (3.09).

Table 9: Dry matter of brinjal at harvest as influenced by different levels and methods of fertilizer application

Treatment		Leaf dry matter (kg ha^{-1})	Fruit dry matter (kg ha^{-1})	Total dry matter (kg ha^{-1})
T_1	Drip fertigation at 75% RDF	1062.16	6122.54	8989.28
T_2	Drip fertigation at 100% RDF	1144.72	7576.34	10626.75
T_3	Drip fertigation at 125% RDF	1242.09	9109.82	12355.94
T_4	Drip fertigation at 150% RDF	1329.39	9421.71	12768.64
T_5	Traditional fertilization at 100% RDF	1004.94	5624.28	8395.98
	SE (m) ±	32.35	395.68	398.64
	CD at 5%	99.67	1219.13	1228.26

Table 10: Cost economics of the study as influenced by different levels and methods of fertilizer application

Treatment	Yield of brinjal (q ha^{-1})	Gross return (Rs ha^{-1})	Total cost (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
T_1 (Drip fertigation at 75% RDF)	443.94	310758	105502	205256	2.95
T_2 (Drip fertigation at 100% RDF)	499.67	349771	113131	236640	3.09
T_3 (Drip fertigation at 125% RDF)	554.88	388414	120761	267653	3.22
T_4 (Drip fertigation at 150% RDF)	557.10	389971	128391	261580	3.04
T_5 (Traditional fertilization at 100% RDF)	428.56	299991	98733	201258	3.04

Conclusion

The study revealed that plant height, number of leaves per plant, number of branches per plant, average weight of fruit, number of fruits per plant, yield of fruits per plant, yield, fruit quality, leaf dry matter, fruit dry matter and total dry matter were recorded highest in treatment T_4 (drip fertigation at 150% RDF) and were found at par with T_3 (drip fertigation at 125% RDF). Also, B:C (Benefit: Cost) ratio was higher in treatment T_3 (drip fertigation at 125% RDF). Hence, drip fertigation at 125% RDF (T_3) along with silver polyethylene mulch was found superior to obtain improved biometric characters, dry matter, fruit quality and highest benefit cost ratio.

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