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BRINJAL (*SOLANUM MELONGENA* L.) CROP RESPONSE TO FERTIGATION LEVELS UNDER SURFACE AND SUBSURFACE DRIP IRRIGATION

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ABSTRACT

A field experiment was conducted to determine the optimum fertilizer requirement through surface and subsurface drip fertigation in brinjal (*Solanum melongena* L.) crop. The brinjal crop was transplanted at 0.6 row to row x 1.2 pair to pair x 0.6 m plant to plant spacing. The drip system was having inline lateral of 4 lph dripper at 0.6 m spacing. Each lateral was kept at 1.8 mspacing, each one served a pair of rows. The irrigation was scheduled at Irrigation water/Crop evapotranspiration of 1.0. The maximum yield of brinjal was found to be 37940 kg/ha under subsurface drip irrigation with 80% Recommended dose of Fertilizer, while in surface drip irrigation it was found 33558 kg/ha with 100% RDF. The maximum benefit cost ratio of 9.07 was found under subsurface drip irrigation with 80% RDF.

***Key word*:** Benefit cost ratio, Brinjal, Subsurface drip irrigation, Surface drip irrigation

Introduction

Drip irrigation is the slow, even application of low-pressure water to soil and plants using plastic tubing placed near the plants' root zone. It is an alternative to sprinkler or furrow methods of irrigating crops. Drip irrigation can be used for crops with high or low water demands. Drip irrigation can help highest water use efficiently. A well-designed drip irrigation system loses practically no water to runoff, deep percolation and evaporation. Drip irrigation reduces water contact with crop leaves, stems and fruit. Thus, conditions may be less favourable for disease development. Irrigation scheduling can be managed precisely to meet crop demands, holding the promise of increased yield and quality. Growers and irrigation professionals often refer to "subsurface drip irrigation" or SDI. When a drip tape or tube is buried below the soil surface, it is less vulnerable to damage during cultivation or weeding. With SDI, water use efficiency is maximized because there is even less evaporation or runoff. Agricultural chemicals can be applied more efficiently with drip irrigation.

Drip irrigation system is one of the advanced methods of irrigation and the use of drip irrigation system has become wide spread in recent years especially in areas where water is scarce. The system is popular in arid and semi-arid regions with high evaporation, scarcity of water and salt problems. Cetin O. and Akalp E. (2019) observed that drip irrigation can be able to save irrigation water from 30% to 50% in case it is properly designed, installed and operated compared to surface irrigation and it can also enable increasing crop yields and crop quality.

Brinjal is one of the most common vegetables grown throughout the country for its purple, green and white pendulous vegetable. It is the member of the Solanaceae family and is closely related to potato and tomato. Brinjal is popular vegetable and is native of India. It can be grown throughout the year in almost all the states of India except at higher altitudes. According to Horticultural Statistics - 2018 India produces about 12.8 Million ton of brinjal from an area of 0.73 Mha (Million ha) with an average productivity of 17.53 t/ha. The brinjal producing states are West Bengal, Orissa, Gujarat, Madhya Pradesh, Bihar,

Chattishgarh, Karnataka, Andhra Pradesh, Maharashtra and Haryana. In Gujarat, brinjal is grown in 0.071 Mha area with production of 1.423 Million ton with 11.89% share of India and productivity of 21.14 t/ha. (Gevariya and Rank, 2022). The major brinjal producing belts in West Bengal are Hoogly, 24-Paraganas and Burdwan.

Material and Methods

Location

The experiment was conducted at the Research-cum-Demonstration Farm, Center of Excellence on Soil and Water Management, Research Testing and Training Centre, CAET, Junagadh Agricultural University, Junagadh. It is located at 21.5°N latitude and 70.44°E longitude with an altitude of 50 meter above mean sea level.

Crop

The brinjal (*Solanum melongena* L.) variety was taken as test crop. The duration of crop was 130 to 150 days.

Treatments

Factor-I: Drip irrigation method (Ii)

I1–Surface drip

I2–Subsurface drip Factor

II: Drip fertigation level (Fi)

F1 - 0.6 RDF

F2 - 0.8 RDF

F3 - 1.0 RDF

Surface and subsurface drip installation

Surface and subsurface drip irrigation systems were installed according to the plan of experiment (shown in Fig. 1) using 16 mm inline laterals with emitters of 4lph discharged spaced at 60 cm. Furrows of 20 cm depths

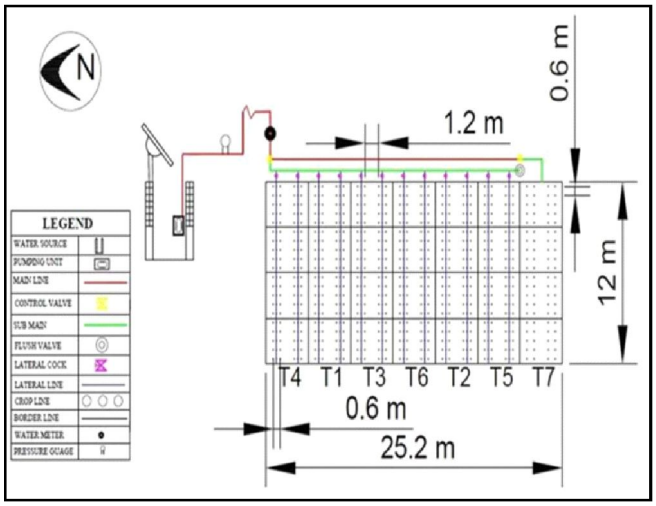

Fig. 1: Field Layout.

Table 1: Details of treatment combinations.

Treatment		Drip irrigation method + Drip fertigation level
T1	I1F1	Surface drip + 60% RDF
T2	I1F2	Surface drip + 80% RDF
T3	I1F3	Surface drip + 100% RDF
T4	I2F1	Subsurface drip + 60% RDF
T5	I2F2	Subsurface drip + 80% RDF
T6	I2F3	Subsurface drip + 100% RDF
T7	Farmers practices as control	Surface (flood) irrigation + 100% RDF

and 12 m lengths were made using a tractor drawn furrow opener. For the subsurface drip irrigation system the laterals were buried at 20 cm depth and were covered with the soil. The drip irrigation system considered of following components:

Main, sub mains and manifolds

Irrigation water was delivered from the well to the field through HDPE mainline of 63 mm diameter. Sub mail lines of 63 mm diameter with control valves were connected to main in order to distribute water to individual plots.

Laterals

The inline laterals of 16 mm diameter having 4 lph dripper discharge and 60 cm dripper spacing were connected to sub main with the help of take off and grommets. The ends of the laterals were closed with end plugs.

Control valve

The control valves were fitted at venturi, filtration unit, by pass assembly and at sub main to divert the water to respective plots during irrigation and fertigation.

Table 2: Agronomical practices.

Sr.	Particulars	Details
1	Crop	Brinjal (*Solanum melongena* L.)
2	Variety	Gujarat Junagadh Long Brinjal - 4 (GJLB-4)
3	Seed rate	0.4 kg/ha
4	Fertilizer dose (N : P : K)	100 : 37.5 : 37.5 kg/ha
5	Weeding	Manually (four time in a season)
6	Irrigation practices	Three days interval as per treatments
7	Fertigation	Applied water soluble N and K fertilizer and
8	Spraying pesticides, insecticides andFungicides	Manually as per disease indication

Filter

In order to have filtering irrigation water, screen and disc filter with the capacity of 40m^3/hr were installed after pumping and fertigation unit, respectively.

Pressure gauges

Pressure gauges were fitted at the control unit for monitoring the fertigation and filtration unit by checking the operating pressures during irrigation and fertigation events.

Venturi manifold

Venturi manifold with 3/4 inches size consisting of gate valve, service saddle and female threaded outlet for venturi inlet-outlet connections as fertilizer injection device was connected to the system. Venturi works on the principle of pressure difference which was created with the help of control valves fitted to the main line.

Results and Discussion

Plant height

The data on the effect of lateral irrigation method and fertigation level on plant height at 30, 60 and 90 DAT along with statistical inferences are presented in Table 3.

Effect of irrigation method on plant height

Different irrigation method significantly influenced the plant height at different days as 30, 60 and 90 DAT (Table 3). At 30 DAT, the highest plant height was observed in I_2(29.33 cm) and the lowest was observed in I_1(25.90 cm). At 90 DAT, the highest plant height was observed in I_2(65.67 cm) and the lowest was observed in I_1 (63.77 cm).

Effect of Fertigation on plant height

The application of fertigation significantly influenced the plant height at different days as 30, 60 and 90 DAT (Table 3). It was observed that the plant height increased with increase in fertigation level. At 30 DAT, the highest plant height was observed in F_3(29.10 cm) and the lowest was observed in F_1(26.10 cm). At 90 DAT, the highest plant height was observed in F_3(66.05 cm) and the lowest was observed in F_1 (63.25 cm).

Table 3: Effect of irrigation method (I) and fertigation level (F) on brinjal height.

(a) Irrigation method			
Treatments	**30 days**	**60 days**	**90 days**
I1	25.90	52.40	63.77
I2	29.33	54.33	65.67
S.Em±	0.59	0.64	0.58
CD	1.74	1.89	1.72
(b) Fertigation level			
F1	26.10^a	51.75^a	63.25^a
F2	27.65^{ab}	53.0^{ab}	64.85^{ab}
F3	29.10^b	55.30^b	66.05^b
S.Em±	0.72	0.78	0.71
CD	2.13	2.31	2.10
INTERACTIONS			
I × F	NS	NS	NS
C.V.	7.35	4.12	3.10

Table 4: Interaction effect of irrigation method (I) and fertigation level (F) on brinjal height.

Sr. No	Plant height at DAT	Fertigation level	Irrigation method	
1	**30**	**Treatments**	I_1	I_2
		F_1	24.5	27.7
		F_2	25.9	29.4
		F_3	27.3	30.9
		S.Em±	1.01	
		CD	NS	
		CV	7.35	
2	**60**	**Treatments**	I_1	I_2
		F_1	50.4	53.1
		F_2	52.2	53.9
		F_3	54.6	56
		S.Em±	1.10	
		CD	NS	
		CV	4.12	
3	**90**	**Treatments**	I_1	I_2
		F_1	62.4	64.1
		F_2	64	65.7
		F_3	64.9	67.2
		S.Em±	1.00	
		CD	NS	
		CV	3.10	

Interaction effect on plant height

Data regarding interaction between irrigation method and fertigation level is presented in Table 4. The result revealed that there was no significant difference observed in plant height due to interaction effect of irrigation method and fertigation level at 30 DAT, 60 DAT and 90 DAT. The highest plant height was observed in treatment T_6(67.20 cm) and lowest in T_1(62.40 cm). This may be due to increase in nutrient levels which enhance nutrient absorption, greater photosynthesis and proper distribution of the generated assimilates. Similar results were reported by Pavan *et al.*, (2021). They observed that subsurface drip irrigation and fertigation regimes caused significant variations on plant height.

Number of fruits per plant

The data on the effect of irrigation method and fertigation level on number of fruits per plant along with statistical inferences are presented in Table 5.

Table 5: Effect of irrigation method (I) and fertigation level (F) on number of fruitper plant.

(a) Irrigation method	
Treatments	**No. of fruits per plant**
I_1	16.11
I_2	18.14
S.Em±	0.4745
CD	1.4097
(b) Fertigation level	
F_1	15.11
F_2	18.32[a]
F_3	17.96[a]
S.Em±	0.5811
CD	1.7266
INTERACTIONS	
S.Em±	0.8218
C.V.%	9.5966

Effect of irrigation method on number of fruits per plant

It is apparent from the data presented in Table 5 that number of fruits per plant was significantly influenced by different methods of irrigation. The number of fruits per plant was found to be highest in I_2 (18.14) and lowest in I_1 (16.11).

Interaction effect

Data regarding interaction between irrigation method and fertigation level on number of fruits per plant are presented in Table 6. The result reveled that there was no significant difference observed in number of fruits per plant due to interaction effect of irrigation method and fertigation level. However, highest number of fruits per plant was observed in treatment T_5 (19.75) and lowest in T_1 (13.67). Esmail *et al.*, (2016) was carried out experiment during 2014 and 2015 to study the effect of subsurface drip irrigation comparing with the surface on yield, number of fruits per tree and fruit quality of orange trees. They found that fruit number per tree was different among different irrigation systems and the subsurface drip irrigation treatment recorded the highest number of fruit while lowest number of fruit was observed in the surface drip irrigation treatment.

Table 6: Interaction effect of irrigation method (I) and fertigation level (F) on no of fruit per plant.

Treatments	Irrigation method	
	I_1	**I_2**
F_1	13.67	16.54
F_2	16.88	19.75
F_3	17.79	18.13
S.Em±	0.8218	
CD	NS	
CV	9.5966	

Table 7: Effect of irrigation method (I) and fertigation level (F) on brinjal yield.

(a) Irrigation method	
Treatments	**No. of fruits per plant**
I_1	31171.33
I_2	35539.33
S.Em±	569.44
CD	1691.95
(b) Fertigation level	
F_1	30469.00
F_2	34632.00[a]
F_3	34965.00[a]
S.Em±	697.42
CD	2072.21
INTERACTIONS	
S.Em±	986.29
C.V.%	5.91

Fruit yield

The data pertaining on the effect of irrigation method and fertigation level on fruit yield (kg/ha) of brinjal are presented in Table 7.

Effect of irrigation method

The application of irrigation significantly influenced the fruit yield (Table 7). The higher fruit yield was found under subsurface irrigation as compared to surface irrigation. The highest fruit yield was observed in I_2(35539.33 kg/ha) and the lowest was observed in I_1(31171.33 kg/ha).

Effect of fertigation level

The application of fertigation significantly influenced the fruit yield at fertigation level (Table 7). It was observed that the fruit yield increased within creased in fertigation level. The highest fruit yield was observed in F_3(34965.00 kg/ha) and the lowest was observed in F_1 (30469.00 kg/ha).

Interaction effect

The observations regarding interaction between irrigation method and fertigation level on fruit yield of brinjal are presented in Table 8. The result reveled that

Table 8: Interaction effect of irrigation method (I) and fertigation level (F) on brinjal yield.

Treatments	Irrigation method	
	I_1	**I_2**
F_1	28632	32306
F_2	31324	37940
F_3	33558	36372
S.Em±	986.29	
CD	NS	
CV	5.9139	

Table 9: Water use efficiency and water saving of brinjal as affected by different treatment.

Yield (kg/ha)	Treatment	Treatment details	Water applied (mm)	WUE (kg/hamm)	Water saving (%)
28632	T_1	I_1F_1	606	47.25	29.53%
31324	T_2	I_1F_2		51.69	
33558	T_3	I_1F_3		55.38	
32306	T_4	I_2F_1		53.31	
37940	T_5	I_2F_2		62.61	
36372	T_6	I_2F_3		60.02	
31896	T_7	Farmers practices as control	860	37.09	-
Note		I_1 : surface drip, I_2 : sub surface drip. F_1, F_2 and $F_3$is 60%, 80% and 100% RDF, respectively			

there was no significant difference observed in brinjal yield due to interaction effect of irrigation method and fertigation level. However, the highest fruit yield was observed in treatment T5 (37940 kg/ha) and lowest in T1 (28632 kg/ha). Similar results were reported by Wang *et al.*, (2022). They found that largest percentage increase in yield in Subsurface drip irrigation as compared to surface drip irrigation and it was observed in crops (6.42%), followed by vegetables (5.29%) and fruits (3.37%), respectively.

The reason for the higher crop performance under 100% RDF was due to recommended dose of fertilizer application which resulted in adequate nutrient availability to plant.

The highest fruit yield (49.8 t/ha), highest net income (2,76,656 /ha) and maximum B:C ratio (2.61) were recorded under the treatment combination of plant spacing of S3-175-50×50 cm with irrigation level I1-100 per cent ET_{crop} and fertigation level F1-100 per cent RDF through drip which was found to be superior over the rest of treatment combinations reported by Ughade and Mahadkar (2015).

Brinjal crop performance under farmer's practice

First irrigation after transplanting was done of 60 mm depth after that 40 mm depth of irrigation water was applied to brinjal crop under surface irrigation treatment (farmer's practice). Second irrigation applied 40 mm depth and 5 days after transplanting. Irrigation was scheduled 40 mm depth at 7 days interval in November, December, January and February, while in March and April months, it was 40 mm depth at 5 days interval. Thus, the total water applied through the season in surface irrigation treatment (farmer's practice) was 860 mm. Full dose of Phosphorus and Potash was given as a basal dose. 50% Nitrogen of RDF applied after 30 days after transplantation and 50% Nitrogen applied at flowering stage in form of Urea.

Table 10: Fertilizer use efficiency under different treatments.

Treat-ment	Yield (kg/ha)	Fertilizer (kg)	FUE (kg/kg-ha)
T_1	28632	105	272.69
T_2	31324	140	223.74
T_3	33558	175	191.76
T_4	32306	105	307.68
T_5	37940	140	271.00
T_6	36372	175	207.84
T_7	31896	175	182.26

Water use efficiency, fertilizer use efficiency, water saving and fertilizer saving

The data regarding water saving and water use efficiency are presented in Table 9. There was a saving in irrigation water to the tune of 29.53% through dripirrigation system as compared to farmer's practice. It shows highest water use efficiency was 62.61 kg/ha-mm reported in subsurface drip irrigation with 80% RDF and lowest was 47.25 kg/ha-mm reported in surface drip irrigation with 60% RDF.

Fertilizer use efficiency

The data on fertilizer use efficiency are given graphically in Table 10, which indicates that I_2 (subsurface drip irrigation) with fertigation level F_1 gave highest fertilizer use efficiency of 307.68 kg/kg-ha and lowest of 182.26 kg/kg-ha under control treatment (farmer's practice).

Treatment's combinations of irrigation method and fertigation treatments are given in Table 10. Higher fertilizer use efficiency was found in combination treatment T_4(307.68 kg/kg ha) and T_1 (272.69 kg/kg-ha) and lower in treatment T_7 (182.26 kg/kg-ha) and T_3(191.76 kg/kg-ha). This is because the yields were comparatively higher and the fertilizers used were lower resulting into higher fertilizer use efficiency. Within the drip system, subsurface drip irrigation gave higher fertilizer use efficiency as compared to surface drip system and conventional method of fertilizer broadcasting. Drip fertigation provides an efficient method of fertilizer delivery and if properly managed it can reduce overall fertilizer application rates and minimizes the adverse environmental

impact on crop production as reported by Fanish and Muthukrishnan (2013).

Fertilizer saving

The comparison results under T_7 treatment (farmer's practice) with T_5 treatment (subsurface drip irrigation with 80% RDF) indicated that 20% fertilizer saving as compared to farmer's practice.

Similar result was found by Sindhu *et al*., (2019). They found rice and wheat needed 20% less N fertilizer under subsurface drip fertigation system to obtain grain yields similar to that under flood irrigated crops.

Conclusion

The maximum Brinjal fruit yield can be 37940 kg/ha and 33558 kg/ha under subsurface and surface drip irrigation when it is fertigated at 80% and 100% RDF. The higher water and fertilizer use efficiency can be obtained as 62.61 kg/ha-mm and 307.68 kg/kg-ha respectively under fertigation of 100% and 60%.

The optimum dose of fertilizer can be 80% and 100% of RDF for brinjal crop if fertigated and irrigated through subsurface and surface drip system. The adoption of subsurface drip system can increase brinjal yield with 20% fertilizer saving over surface drip.

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