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Neelakanth JK
Professor and Head, Department of Agril. Engineering, College of Agriculture, Hanumanamatti, UAS, Dharwad, Karnataka, India

SS Gundlur
Assistant Professor, Soil Sciences and Chemistry, College of Agriculture, UAS, Dharwad, Karnataka, India

Rajkumara S
Professor, Dept of Agronomy College of Agriculture, UAS, Dharwad, Karnataka, India

Corresponding Author:
Neelakanth JK
Professor and Head, Department of Agril. Engineering, College of Agriculture, Hanumanamatti, UAS, Dharwad, Karnataka, India

Effect of paired row technique using drip irrigation system on brinjal in *Vertisols* of Malaprabha command in Northern Karnataka

Neelakanth JK, SS Gundlur and Rajkumara S

Abstract
A field experiment was conducted during 2015-16 and 2016-17 to compare the paired row technique and normal drip irrigation system on brinjal in *Vertisols* of Malaprabha command in Northern Karnataka. Drip system with irrigation treatment as 1.0 Etc, 0.8 ETc and 0.6 ETc in the paired row technique and normal drip system were considered along with farmers method as check was considered for the study. Normal row (22.74 $T.ha^{-1}$) and paired row drip system yields (21.16 $T.ha^{-1}$) brinjal which is on par with farmers method (19.15 $T.ha^{-1}$). The water use efficiency was maximum 41.17 Kg. $(ha.mm)^{-1}$ with paired layout and with farmers method was recored 41.4 Kg. $(ha.mm)^{-1}$ but also which is on par with normal drip system method of irrigation 38.7 Kg. $(ha.mm)^{-1}$. The gross and net income was recorded maximum (Rs 186080 ha^{-1} and Rs 86250 ha^{-1}) in normal drip system and also this was on par with the paired row and farmers method of irrigation. The B:C ratio was maximum (2.07) in case of normal system which was recorded non-significant with the other treatments. The superior water use efficiency was recorded with 0.6 ETc (46.51 Kg. $(ha.mm)^{-1}$). Interaction effect between irrigation 0.8 ETc with normal row drip system was also recorded superior water use efficiency (46.51 Kg. $(ha.mm)^{-1}$. The overall water saving was recorded about 12.89 percent, 22.31 percent and 42.34 percent with 1.0 ETc 0.8 ETc, and 0.6 ETc respectively compared with farmers method.

Keywords: Drip irrigation, paired and normal row technique, irrigation water depths, brinjal crop yield, water use efficiency (WUE), water sav

Introduction
Brinjal or egg plant (*Solanum melongena* L.) belonging to the family Solanaceae is the native of India. It is one of the most popular and important vegetable grown in almost all parts of India except in higher altitudes. It is a popular vegetable with all the people and hence it is rightly called the vegetable of the masses. Brinjal has got high nutritive value, as it contains 92.70 g moisture, 1.4 g protein, 0.30 g fat, 0.30 g minerals, 0.30 g fiber, 4.0 g carbohydrates, 18.0 mg calcium, 18.0 mg oxalic acid, 47.0 mg, phosphorus, 2.0 mg potassium, 124 I.U. vitamin 'A', 0.11 mg riboflavin and 12.0 mg vitamin C per 100 g of edible portion (Choudhary, 1967) [2].

Drip irrigation system is one of the advanced methods of irrigation. The system is popular in arid and semi arid regions with high evaporation losses. In drip irrigation water is conveyed through network of pipes up to root zone of crop and applied through emitters, frequently and with a volume approaching the consumptive use of plants and thereby minimizing conventional losses as deep percolation and evaporation from soil which give better water use efficiency. The extent of water saved in subsurface drip is about 20 percent more to the normal (Martinez and Reca 2014) [4]. Drip irrigation can save water up to 40 to 70 per cent as well as increasing the crop production to the extent of 20 to 100 per cent (Reddy and Reddy, 2003) [6].

Crop geometry and drip layout plays important role in obtaining high yield. Optimum plant population for brinjal crop varies considerably due to environment under which it is grown. It is not possible to recommend a generalized optimum plant population since a crop gives better response to specific management practices. Therefore, it is very necessary to quantify optimum plant population by adjusting the drip lay out. In view of above points, an experiment was proposed to study of cost effective layout of drip and effect of irrigaton and on brinjal (*Solanum melongena* L.).

Materials and Methods
A field experiment was conducted at Irrigation Water Management Research Centre, Belvatagi during *kharif 2015-16 and 2016-17*. The research centre comes under Northern dry zone of Karnataka. The soil type is clay in texture with pH of 8.20, organic carbon 0.45 per cent and.

EC 0.27 dS/m. The initial available N, P_2O_5 and K_2O of the soil were 220, 34.5 and 710 kg ha^{-1}, respectively. The values of field capacity and bulk density were 40.5 per cent and 1.35 g/cc, respectively. Split plot design was adopted with four replications. In the main plots two irrigation methods (M_1 = normal surface drip and M_2 = paired row surface drip) and in sub plots three Etc. levels (I_1 = 1.0 Etc. I_2 = 0.8 Etc. and I_3 =0.6 Etc.) along with control (surface irrigation at 0.6 IW/CPE ratio) were included. Brinjal crop seedlings (Manjari breed) were planted. with spacing of 60 cm x 90 cm Scheduling of irrigation was done at three days frequency based on Etc. levels. The volume of water was calculated as: $Q = Ep \times Kp \times Kc \times S_1 \times S_2$ where, Q, quantity of water to be given/dripper (litres); Ep, pan evaporation (mm); Kp, pan co-efficient (0.7); Kc, crop co-efficient; Design Plan and layout of the experiment was considered as the Gross plot size (4.5 m X 4.5 m); Net plot size (2.7m X 2.7m). The Normal row drip system layout 90 X 90 cm and Paired row drip system 50-150-50 cm S_1, lateral spacing (90 cm) and S_2, dripper spacing (0.6 m). Spilt plot design was considered for statistical analysis.

The irrigation was scheduled based on pan evaporation of data with interval of alternate day. The volume of water applied was calculated by using following formula. (Vermeiren and Jobling, 1980) [8]. V= Ep x Kp x Kc x A x Aw where, V- Volume of water to be applied, lit/alternate day/plot, Ep- Pan evaporation of previous two days, mm, Kp- Pan factor (0.7), Kc- Stage wise crop coefficient, A- Area of plot m^2, Aw- Wetted area for brinjal (0.75). The operation time of drip unit (T) was calculated by using the formula (Pawar, 2001) [5].

$$T = \{V / [q \text{ X } Ne]\} \times 60$$

Where, T= Operation time of system (min), V= Volume of water to be applied, lit/alternate day/plot, q= Average emitter discharge (l.p.h), Ne= Number of Emitter per plots

For the control check farmers method of irrigation was applied to the crop with depth of 6 cm, IW/CPE=1.0. For the experimental treatments fertigation was given as per POP recommendations the N, P and K were given at interval of 30, 60 and 90 DAT through 19:19:19 grade and remaining quantity of N was given through urea by calculating the quantity of fertilizer.

In brinjal Kc values considered were 0.45, 0.75, 1.15 and 0.70 for initial (0–25 DAS), development stage (26–70 DAS), fruit development (71–120 DAS) and maturity stage (121-harvest) respectively as per FAO Irrigation Water Management Training Manual No. 3 (1986) (Reddy and Reddy 2003) [6]. Time of irrigation was as per the discharge of water per dripper. In control, six cm depth of irrigation was given on the basis of cumulative pan evaporation (100 mm CPE). The control treatment was compared with the treatment combinations of main and sub plots by using Randomized Block Design.

Results and Discussion

Crop yield and B:C ratio

Brinjal yield did not differ significantly due to method of irrigation (Table 1). The normal drip irrigation recorded numerically higher brinjal yield 22.74 ton. ha^{-1} than paired row drip irrigation 21.16 ton. ha^{-1}. The corresponding gross income, net income and B:C ratio were Rs.182000 ha^{-1}, Rs.86250 ha^{-1} and 1.974 respectively recorded with normal drip irrigation. These results were on par with the paired row drip system as well as farmers method. However, normal drip irrigation increased the brinjal yield by 7.46 per cent over paired drip irrigation. These results are in conformity with Kalfountzos *et al*. (2007) [3]. In the present investigation year 2015 at IWMRC Belavatagi, rainfall of 392.6 mm can be considered as wet year for brinjal cultivation. These contrasting results were mainly attributed to variation in the rainfall pattern during the reproductive stages of the crop (51.2 mm during developmental stage (26-70 DAS), 291.6 mm during fruit development stage (76-120 DAS) and it coincided with high effective rainfall of 151 mm throughout crop growth period. Irrigation treatments with 1.0 Etc. 0.8 Etc. and 0.6 Etc. recorded non significant yields as 23.90 ton.ha^{-1}, 21.45 ton.ha^{-1} and 19.39 ton.ha^{-1} respectively (Table.2). The corresponding water use efficiency 38.7 kg ha^{-1}, 41.7 kg ha^{-1} and 41.4 kg ha^{-1} were recorded which are on par with each other also. Higher gross income, net income and B:C ratio was recorded with the treatment 1.0 Etc. Rs.182350 ha^{-1}, Rs.86125 ha^{-1} and 2.11 respectively which are on par with other treatment also.

Interaction effect between method of layout and Etc. levels was found non- significant with paired row and 0.6 Etc. (Table. 3). Scheduling of irrigation at 0.8 Etc. with normal drip irrigation recorded higher brinjal yield 22.66 ton. ha^{-1}. These results recorded on par with paired row technique as well as other drip system. The treatment with paired row and 0.6 Etc. level recorded 22.56 ton. ha^{-1} brinjal yield. The farmer's method of irrigation recorded low brinjal yield 19.57 ton. $ha^{-1.}$ All the results of WUE, Gross income, net income and B:C ratio were recorded non significant results. Hence, paired row technique will be the best way of saving the amount as well as water.

Total water use and water use efficiency

The total water depth used by the crop (Table.4) was higher in farmers method using furrow irrigation (626.77 mm) as against drip irrigation regimes under 1.0 Etc. (545.95mm) under 0.8 Etc. and (486.91 mm) under 0.6 Etc. (352.27 mm). The amount of depth of water required for brinjal ranges from 560 to 900 mm for different places or different varieties, depending on duration, soil and climatic conditions. As the brinjal yield was comparable with furrow irrigation, considerable saving in water use was possible by adopting drip irrigation. The water saving in 1.0, 0.8 and 0.6 Etc. levels were 12.89, 22.31 and 42.34 per cent respectively compared to furrow irrigation (Table.4).

The data on water use efficiency is also presented in Table 1 & 2. Water use efficiency did not differ significantly due to method of irrigation (Table.1). Water use efficiency was found higher in paired row drip irrigation (41.7 kg ha^{-1} mm) and increase was by 7.75 per cent over normal drip irrigation. These results are in conformity with Abdrabbo (2013) [1]. at Egypt. Irrigation scheduled using Etc. level differed significantly as irrigation scheduled at 0.6 Etc. (5.65 kg ha^{-1} mm) recorded significantly higher water use efficiency. Next best water use efficiency was in 0.8 Etc. (41.68 kg ha^{-1} mm) and was significantly higher than 1.0 Etc. (34.40 kg ha^{-1} mm). Low brinjal yield (19.39 ton. ha^{-1}) was recorded and limited quantity of water applied under 0.6 Etc. (352.27 mm). Amount of water applied varies based on Etc. levels. In normal drip irrigation as well as paired row drip at 1.0 Etc. (545.95 mm), 0.8 Etc. (488.91mm) and 0.6 Etc. (353.27 mm) of water was applied. Among different treatment combinations (Table. 3) significantly higher water use

efficiency of 46.51 kg. ha^{-1}.mm) was registered with normal drip irrigation with 0.8 ETc. This result also on par with other drip irrigation with 0.6 ETc. Increase in the level of water application by drip irrigation decreased the water use efficiency, while limited quantity of water applied under lower drip irrigation regime increased brinjal yield, due to higher moisture content at all stages. These results were in harmony with Veeraputhiran and Chinnuswamy (2009) [7]. Surface irrigation at 0.6 IW/CPE ratio recorded water use efficiency (41.4 kg ha^{-1} mm).

Table 1: Effect of method of layout using drip irrigation system on Brinjal yield, water use efficiency, gross income, net income and B:C ratio

Method of Layout	Brinjal Yield, (Ton/ha)			WUE Kg(ha.mm)$^{-1}$			Gross Income. Rs.ha^{-1}			Net-Income Rs.ha^{-1}			B:C ratio		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
M_1=Normal drip system	22.24	23.26	22.74	31.30	38.5	38.7	177920	186080	182000	85952	86548	86250	2.01	2.15	2.07
M_2=Paired row drip system	20.69	21.63	21.16	42.56	39.8	41.7	165520	173040	169280	84882	85065	84973	1.95	1.99	1.97
Control / Check AAF 0.6 IW/CPE	19.75	18.55	19.15	40.53	42.5	41.4	158000	148400	153200	84043	78163	81103	1.88	1.96	1.92
SEm+	3.07	2.98	3.02	3.25	2.98	3.11	13203	13808	13505	13203	13808	13505	0.114	0.135	0.124
CD (0.05)	9.47	9.84	9.65	9.76	9.94	9.34	39609	41426	40517	39609	41426	40517	0.511	0.611	0.561

Table 2: Effect of drip irrigation levels on brinjal yield, water use efficiency, gross income, net income and B:C ratio

Treatment Irrigation levels	brinjal Yield, (Ton.ha^{-1})			WUE Kg(ha.mm)$^{-1}$			Gross Income. Rs.ha^{-1}			Net-Income Rs.ha^{-1}			B:C ratio		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
I_1 = 1.0 ETc	23.24	24.56	23.90	31.30	37.5	34.40	178420	186280	182350	85985	86548	86125	2.07	2.15	2.11
I_2 = 0.8 ETc	20.66	22.24	21.45	43.56	39.8	41.68	166520	173240	169880	84782	85065	84923	1.96	2.03	1.99
I_3 = 0.6 ETc	19.33	19.45	19.39	45.53	47.5	46.51	156800	148600	152700	84103	78193	81148	1.86	1.90	1.88
SEm+	3.07	2.98	3.02	3.25	2.98	3.11	13103	13708	13405	13203	13808	13505	0.13	0.124	0.127
CD (0.05)	9.47	9.84	9.65	9.76	9.94	9.34	39609	41456	40532	39609	41426	40517	0.39	0.372	0.381

Table 3: Interaction effect between drip and method of layout of irrigation system on brinjal yield, water use efficiency, gross income, net income and B:C ratio

Method of Layout	Brinjal Yield, (Ton.ha^{-1})			WUE Kg.(ha.mm)$^{-1}$			Gross Income. Rs.ha^{-1}			Net-Income Rs.ha^{-1}			B:C ratio		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
I_1M_1	21.80	23.36	22.58	31.30	37.5	34.40	178920	186680	182800	85685	86848	86266	2.08	2.14	2.26
I_1M_2	22.53	22.56	22.54	43.56	39.8	41.68	165620	173240	169430	84682	85565	85123	1.95	2.02	1.87
I_2M_1	21.97	23.36	22.66	45.53	47.50	46.51	158600	148500	153550	84223	78293	81258	1.88	1.89	2.07
I_2M_2	19.28	24.65	21.96	31.30	38.5	38.7	178620	186580	182600	85982	86648	86315	2.07	2.15	2.32
I_3M_1	21.59	21.56	21.57	42.56	39.8	41.7	166620	173440	170030	84982	85165	85073	1.96	2.03	1.80
I_3M_2	20.55	24.58	22.56	40.53	42.5	41.4	156900	148800	152850	84143	78363	81153	1.86	1.89	2.07
Control	19.50	19.65	19.57	18.50	19.85	19.66	156000	144400	150200	83043	77163	80103	1.87	1.87	1.80
SEm+	3.27	2.85	3.06	3.25	2.98	3.11	13303	13608	13455	13303	13608	13455	0.18	0.19	0.18
M X S CD (0.05)	9.81	8.55	9.18	9.76	9.94	9.34	39709	41356	40532	39709	41356	40532	0.54	0.57	0.55

Table 4: Percentage saving of water for the brinjal crop

Treatment	Depth of water irrigated (mm)			Effective rainfall (mm)			Total Depth of irrigation (mm)	saving of water (%)
Irrigation levels	2015-16	2016-17	Mean	2015-16	2016-17	Mean		
I_1 = 1.0 ETc	485	477	481	63.21	66.71	64.95	545.95	12.89
I_2 = 0.8 ETc	399	365	382	99.56	110.26	104.91	486.91	22.31
I_3 = 0.6 ETc.	298	278	288	65.23	63.31	64.27	352.27	42.34
Control / farmers method of irrigation	563	555	559	68.23	67.31	67.77	626.77	--

Conclusion

The results of the experiment inferred and was concluded that the adoption of paired row surface drip technique method of irrigation at 0.8 Etc. was proved to be cost effective and water use efficiency resulted in recording higher brinjal yield, water use efficiency and water saving in comparison surface or farmers method of irrigation under *vertisols*.

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