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Evaluation of Drip Irrigation System and Fertigation of Nitrogen in Sugarcane

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Abstract

Field experiments conducted in sugarcane revealed that scheduling irrigation through drip daily at 80 percent of pan evaporation (PE) registered the highest cane yield (168.2 t ha^{-1}) in main of cv. CO 86032 which was followed by 60 and 40 percent drip irrigation (148.5 and 140.9 t ha^{-1} respectively) and were significantly superior over surface method of irrigation at 0.75 IW/CPE ratio (126.2 t ha^{-1}). In the ratoon crop, drip irrigation treatments at 40, 60 and 80 percent level of pan evaporation produced comparable cane yields (124.4, 131.7 and 128.9 t ha^{-1} respectively). Highest water use efficiency was observed in 40% PE treatment for both main crop and ratoon (150.3 and 146.8 kg ha mm^{-1} respectively). Nitrogen levels did not show any marked difference on cane yield and application of 175 kg N ha^{-1} as fertigation was found to be optimum and economical.

1. Introduction

Water is the most critical input for agricultural productivity, and efficient water use is crucial to the development of sustainable agriculture. Efficient irrigation calls for practices that will minimize the available losses in storage, conveyance and applications and thus provide a higher percentage of water for actual use by the irrigated crops. Drip irrigation system which increases the water use efficiency to a greater extent is the proper means to manage the water scarcity regions to increase the crop productivity.

Drip irrigation has proved to be a success in terms of less water and increased yield in a wide range of crops (Bhardwaj, 2001). This system is generally most successful for high income crops that would have shorter pay-back period. The use efficiency of both water and fertilizers could be increased substantially through drip irrigation and fertigation. Combined application of water and fertilizers is ideal for proper crop growth with the irrigation water acting as a carrier for the nutrients required by crops (Bhuvaneswari *et al.,* 2019). In the present study, an attempt has been made to evaluate the relative efficiency of drip irrigation in sugarcane in conjunction with fertigation of nitrogen in sugarcane.

2. Materials and Methods

The experiment was conducted at Agricultural Research Station, Bhavanisagar, Tamil Nadu. Sugarcane cv. CO 86032 was the test variety used for the study in main and ratoon crops. The experiment was laid out in split plot design with three replications. In the main plot, surface irrigation at 0.75 IW/CPE ratio to 5 cm depth was compared with drip irrigation at three levels viz., drip irrigation daily at 80%, 60% and 40% of pan evaporation (PE). In the sub plot, the recommended level of 225 kg N ha^{-1} was compared with 275 and 175 kg N ha^{-1}. Nitrogen was applied through irrigation water using venturi attachment in drip treatments and as band placement in surface irrigated plots.

The soil of the experimental site was moderately deep, well drained, red sandy loam with medium in available N and P and high in available K. For surface irrigation method, the recommended spacing of 90 cm between rows was adopted under ridges and furrow method of irrigation. For drip irrigation treatments, paired row method of planting was adopted in which the spacing between two rows of crop was 60 cm between which the laterals were laid and the spacing between pairs of rows was 150 cm. Drippers of 4 lph capacity were fitted at 60 cm spacing along the lateral line. The quantity of water in drip irrigation treatments was worked out based on daily pan evaporation value.

Nitrogen was applied as urea at the levels described under each treatment through drip system for the drip irrigation

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treatments and as conventional band placement for surface irrigation treatment. Phosphorus and potassium fertilizers were applied at 62.5 and 112.5 kg ha^{-1} respectively as single super phosphate and muriate of potash as band placement. Nitrogen and potassium were applied in three equal splits on 30, 60 and 90 days after planting while entire dose of phosphorus was applied as basal at the time of planting. All other cultural operations were commonly followed as per recommendations. The crop was harvested at maturity and cane yield data was recorded. Total water used and water use efficiency were computed for the irrigation treatments.

3. Results and Discussion

3.1 Cane Yield

The millable cane yield recorded in main and ratoon crops are presented in Table 1. The cane yield of main crop of CO 86032 revealed that the irrigation levels greatly influenced the yield and irrigation through drip at 80% of pan evaporation registered the highest cane yield which was superior compared to other levels. This was followed by irrigation through drip at 60% and 40% of PE and the yields were significantly superior over surface method of irrigation. Surface irrigation scheduled at 0.75 IW/CPE ratio recorded the lowest cane yield which was inferior to all the drip irrigation treatments.

Table 1: Cane yield (t ha^{-1}) as influenced by the treatments

Treatments	Cane yield (t ha^{-1})	
	Main Crop	Ratoon Crop
a) Irrigation regimes		
Surface irrigation 0.75 IW/CPE	126.2	106.0
Drip daily at 80 % PE	168.2	128.9
Drip daily at 60 % PE	148.5	131.7
Drip daily at 40 % PE	140.9	124.4
CD (P = 0.05)	4.2	11.7
b) Levels of N		
175 kg N ha^{-1}	145.5	122.4
225 kg N ha^{-1}	145.2	124.3
275 kg N ha^{-1}	147.2	121.6
CD (P = 0.05)	NS	NS

In the ratoon crop of CO 86032, the drip irrigation treatments at 40, 60 and 80% level of pan evaporation produced comparable cane yields and the yields were significantly superior over surface irrigation. Surface irrigation scheduled at 0.75 IW/CPE ratio recorded the lowest cane yield of 106 t ha^{-1}.

It is quite obvious that continuous application of water and fertigation of nitrogen at optimum level would result in higher yield under drip system of irrigation. In drip system, the soil is kept always at near to field capacity, favouring, good growth without stress to the plants. But in surface irrigation, irrigation is given once in 7-10 days, wherein the crop is under stress in the later 3-5 days which affects the growth and yield. Bhardwaj (2001) reported 100% yield increase in banana, 40 to 50 percent in sugarcane, pomegranate and around 25% in grapes and cotton under drip method of irrigation. Selvaraj *et al.* (1997) reported 32% yield increase in sugarcane under drip irrigation system over surface method. In the present study, the yield increase in drip irrigation scheduled daily at 80% of PE was 19% when compared to surface irrigation in main crop. Similarly, scheduling irrigation through drip at varying levels resulted in considerable yield increase with judicious use of irrigation water.

3.2 Effect of Fertigation on Cane Yield

The yield increase was computed in the main crop and the results are shown in Table 2, to evaluate the effect of application of fertilizer nitrogen through fertigation in comparison with traditional band placement. The cane yield recorded under drip irrigation at 80% of PE with the application of the recommended dose of 225 kg N ha^{-1} as fertigation was 169.2 t ha^{-1}. But under surface irrigation the yield obtained was only 122.7 t ha^{-1} for the same level of nitrogen applied through band placement. Thus, yield increase due to fertigation was 37.9% compared to conventional practice and the mean yield increase due to fertigation was 33.2, 17.6 and 11.6 percent in 80, 60 and 40% of drip irrigation respectively. Nitrogen fertilizer could be reduced by 30% through drip fertigation in sugarcane as against the standard practice of buying along the cane rows (Kwong *et al*., 1999; Manikandan *et al.,* 2019) reported that. In banana, the results indicated that as high as 60% nitrogen fertilizer could be saved through fertigation without significant ill effect on crop yield (Parikh *et al*., 1994).

Table 2: Effect of fertigation on cane yield (t ha^{-1})

Irrigation levels	Levels of N (kg ha^{-1})			
	175	225	275	Mean
Surface irrigation, 0.75 IW/CPE	125.9	122.7	129.9	126.2
Drip daily at 80% PE	165.1 (31.1)	169.2 (37.9)	170.1 (30.9)	168.1 (33.2)
Drip daily at 60% PE	148.1 (17.6)	150.1 (22.3)	147.1 (13.2)	148.4 (17.6)
Drip daily at 40% PE	142.7 (13.3)	138.7 (13.0)	141.4 (8.9)	140.9 (11.6)
Mean	145.5	145.2	147.1	

(Figures in parenthesis denotes percent increase in yield under fertigation over band placement of nitrogen)

It is quite obvious that higher rate of nitrogen and irrigation water would result higher yield under drip irrigation. On the contrary, it is interesting to note that even under lower rate of water supply *viz.,* 40% of irrigation through drip and

at the lower dose of 175 kg N ha^{-1} the yield recorded was 142.7 t ha^{-1} which was quite comparable with the of 60% of irrigation through drip with 275 kg N ha^{-1} (147.1 t ha^{-1}). The yield reduction was only 3.1%, but this has achieved a total water saving of 20% besides saving 57% nitrogenous fertilizer. Thus, fertigation of nitrogen through drip resulted in saving of fertilizer to the tune of 50 kg N ha^{-1} during the experimentation. In normal application of fertilizers, there is more chance for leaching and movement of fertilizers beyond the root zone due to excessive water application. But through drip, water is applied at required quantities and hence there won't be leaching or wastage of fertilizer.

3.3 Water Use Efficiency

Total water used during the crop period was quantified and water use efficiency was worked out for the main and ratoon crops and presented in Table 3. In the main crop, irrigation water saving was 19.3, 39.2 and 58.3% in drip irrigation scheduled at 80, 60 and 40% of PE compared to surface irrigation at 0.75 IW/CPE ratio. The total water used under surface irrigation was 1806 mm for the whole cropping period inclusive of irrigation water applied and effective rainfall as against 1518 mm under 80% drip, 1222 mm under 60% drip and 938 mm under 40% drip irrigation treatments. The water use efficiency was 56 to 115% higher in drip irrigation treatments compared with that of surface irrigation. In the ratoon crop of sugarcane also, a similar trend in saving of irrigation water in drip treatments over surface irrigation was observed. The results are in conformity with the findings in sugarcane (Selvaraj *et al.,* 1997; Thiyagarajan *et al.,* 2011). In banana, saving in irrigation water to the tune of 70 percent was reported besides improvement in yield and quality (Upadhyay, 1995) and Bhardwaj (2001) reported 40 to 70% saving in irrigation water through drip irrigation in a wide range of crops.

Based on the results, it is suggested that in moderate water scarcity areas, drip irrigation daily at 80% or 60% of PE with fertigation of 225 kg N ha^{-1} could be recommended for enhancing productivity of cane with judicious use of irrigation water. In areas where water is very scarce, drip irrigation daily at 40% of PE and 175 kg N ha^{-1} through fertigation could be efficient and economical over surface irrigation.

Table 3: Total water used and water use efficiency

Particulars	Surface irrigation	Drip at 80% PE	Drip at 60% PE	Drip at 40% PE
Main Crop				
Irrigation water applied (mm)	1490	1202	906	622
Irrigation water saving (%)	-	19.3	39.2	58.3
Effective rainfall (mm)	316	316	316	316
Total water used (mm)	1806	1518	1222	938
Cane yield (t ha^{-1})	126.2	168.2	148.5	140.9
Water use efficiency (kg ha mm^{-1})	69.9	108.8	121.5	150.3
% increase in WUE	-	55.7	73.8	115.0
Ratoon crop				
Irrigation water applied (mm)	1180	944	712	509
Irrigation water saving (%)	-	20.0	39.7	56.9
Effective rainfall (mm)	336	336	336	336
Total water used (mm)	1516	1280	1048	845
Cane yield (t ha^{-1})	106.0	128.9	131.7	124.4
Water use efficiency (kg ha mm^{-1})	69.9	100.8	125.9	146.8
% increase in WUE	-	44.2	80.1	110.0

4. Conclusion

Irrigation scheduling with drip irrigation daily at 80% of PE registered the highest cane yield in the crop main but in the ratoon crop drip irrigation treatments at 40, 60 and 80 percent level of pan evaporation produced comparable cane yields. Highest water use efficiency was observed in 40% PE treatment for both main crop and ratoon. There was no significant effect of nitrogen levels on cane yield was observed and application of 175 kg N ha^{-1} as fertigation was found to be optimum and economical.

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