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Evaluation of Irrigation Systems for Cost Reduction in Wide Spaced Sugarcane

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Abstract

Field experiments were conducted at Agricultural Research Station, Tamil Nadu Agricultural University, Bhavanisagar, Tamil Nadu, India to evaluate the irrigation systems for cost reduction in wide spaced sugarcane during 2000-2004. The results revealed that, drip irrigation at 60% PE with one lateral row^{-1} significantly recorded higher sugarcane yield of 164.8 t ha^{-1} with enhanced water use efficiency of 166.1 kg ha^{-1} mm^{-1} and highest net returns of ₹ 83,650 ha^{-1}. Among the surface irrigation treatments, irrigation at 1.0 IW/CPE ratio recorded the maximum yield of 140.1 t ha^{-1} with a WUE of 90.7 kg ha^{-1} mm^{-1}.

1. Introduction

Water is the most important and limiting factor among the multiple factors that contribute to the crop growth and yield. Further the response to applied fertilizers depends up on the quantity and frequency of water applied through irrigation. Since there is only a limited scope for further exploitation of irrigation water sources, there is a greater need for efficient use of water and its management attains paramount importance in irrigation agriculture.

In India, drip irrigation was introduced in the early seventies and the development has taken place only in the eighties. Drip irrigation eliminates the conveyance loss completely and maintains the moisture in the root zone of crop. Drip irrigation has also brought a major change in fertilizer delivery techniques such as fertigation. It allows the nutrients exactly to the root zone and increase the use efficiency of both water and fertilizer nutrient (Desmukh et al., 1996).

Drip fertigation is found to be the most efficient practice for sugarcane and offers wide range of benefits. Earlier studies conducted to find out the importance of drip irrigation revealed that, sugarcane consumes half the water requirement compared to other surface methods (Chandia and Yaseen, 1995). Recently altering the crop geometry by providing wider spacing (150 cm row spacing), increased the feasibility of mechanical harvesting and cane weight^{-1}. Hence water and nutrient management for the wide spaced sugarcane need to be studied and optimized. Thus the present investigation was taken up to optimize the irrigation system for reducing the cost of drip irrigation in wide spaced sugarcane.

2. Materials and Methods

Field experiments were conducted at Agricultural Research Station, Tamil Nadu Agricultural University, Bhavanisagar, Tamil Nadu (638 451), India with sugarcane variety CO 86032 during 2000-2004 to economize the irrigation water through various irrigation systems under wider row spacing. Scheduling irrigation at 75% of cumulative pan evaporation (CPE) to 5 cm depth under traditional method of planting was compared with four levels of irrigation viz., 5 and 7 cm depth at 75 and 100% CPE under furrow as well as alternate furrow method of irrigation. In drip system, irrigation at 80, 60, 40% of CPE with one lateral each row^{-1} and one lateral two rows^{-1} were tried. There were totally fifteen treatments viz; T_1 : 0.75 IW/CPE surface irrigation at 5 cm under normal planting; T_2: 0.75 IW/CPE surface irrigation at 5 cm under wider row spacing; T_3: 0.75 IW/CPE surface irrigation at 7 cm under wider row spacing; T_4: 0.75 IW/CPE surface irrigation at 5 cm

under wider row spacing, alternate furrow; T_5: 0.75 IW/CPE surface irrigation at 7 cm under wider row – alternate furrow; T_6: 1.00 IW/CPE surface irrigation at 5 cm under wider row; T_7: 1.00 IW/CPE surface irrigation at 7 cm under wider row; T_8: 1.00 IW/CPE surface irrigation at 5 cm under wider row – alternate furrow; T_9: 1.00 IW/CPE surface irrigation at 5 cm under wider row – alternate furrow; T_{10}: 80% PE drip irrigation once in 2 days under wider row – one lateral row^{-1}; T_{11}: 60% PE drip irrigation once in 2 days under wider row – one lateral row^{-1}; T_{12}; 40% PE drip irrigation once in 2 days under wider row – one lateral row^{-1}; T_{13}: 80% PE drip irrigation once in 2 days under wider row – one lateral 2rows^{-1}; T_{14}: 60% PE drip irrigation once in 2 days under wider row – one lateral 2rows^{-1}; T_{15}: 40% PE drip irrigation once in 2 days under wider row – one lateral 2rows^{-1}. replicated thrice in a randomized block design. The recommended dose of fertilizers was 275: 62.5: 112.5 kg ha^{-1} of NPK for plant crop and 25% extra nitrogen for ratoon crop for surface irrigation. In drip irrigation 275 and 112.5 kg ha^{-1} of N and K was applied in 14 equal splits with 15 days interval from 15 days after planting. Water Use Efficiency (WUE) is defined as the ratio of yield

$$\text{Water use efficiency (WUE)} = \frac{Y}{ET}$$

ha^{-1} to seasonal water consumption. It was calculated using the methodology provided by Tanner and Sinclair (1983).

where,

Y = yield (kg ha^{-1})

ET = actual evapotranspiration (mm)

$$\text{Sustainable yield index (SYI)} = \frac{\overline{Y} - \delta}{Y_{max}}$$

Sustainable Yield Index (SYI) was calculated by using (Wanjari et al., 2004)

$\overline{Y}$ = average yield over years (t ha^{-1})

δ = standard deviation

Y_{max} = maximum yield obtained with any treatment

3. Results and Discussion

3.1. Cane yield

Pooled cane yield of the crop indicated that, drip irrigation performed better in increasing the yield than surface irrigation method (Table 1). Among the irrigation systems, drip irrigation once in two days at 60% PE for a wider row spacing with one lateral row^{-1} (T_{11}) recorded the highest cane yield of 164.8 t ha^{-1} which was followed by drip irrigation at 80% PE (T_{10}) followed by drip irrigation at 60% PE (T_{14}) with one lateral two rows^{-1}. The yield increase was 34.6% over conventional surface irrigation method. Among surface irrigation treatments, irrigating the crop at 5 cm depth at 1.00 IW/CPE ratio for wider row spacing (T_6) of sugarcane registered the highest cane yield of 140.1 t ha^{-1}. The yield increase was 14.5% over normal surface irrigation. Lowest yield was recorded in the

Table 1: Effect of treatments on cane yield (t ha^{-1}), economics and water use efficiency (WUE) of irrigation systems

Trt no.	CY	RCY	AY	SYI	CY	GR	NR	B/C ratio	ER	TWU	WUE
T_1	137.2	107.6	122.4	0.65	27500	87372	59872	3.17	310.5	1336	92.3
T_2	130.0	110.3	120.2	0.63	24500	85257	60757	3.47	310.5	1336	91.2
T_3	105.2	115.0	110.1	0.57	24500	89262	64762	3.64	315.8	1286	86.4
T_4	124.0	122.0	123.0	0.65	24500	93960	69460	3.83	319.3	1146	112.1
T_5	126.1	117.9	122.0	0.64	24500	91890	67390	3.75	315.8	1068	119.6
T_6	151.9	128.4	140.1	0.75	24500	102240	77740	4.17	274.5	1575	90.7
T_7	122.7	124.9	123.8	0.65	24500	100530	76030	4.10	298.5	1521	81.7
T_8	121.8	106.1	114.0	0.59	24500	87678	63178	3.57	274.5	1312	92.8
T_9	116.6	113.6	115.1	0.60	24500	96750	72250	3.94	298.5	1254	95.2
T_{10}	165.2	139.6	152.4	0.83	36500	111510	75010	3.05	290.5	1351	113.9
T_{11}	183.8	145.8	164.8	0.90	36500	120150	83650	3.29	290.5	1115	148.3
T_{12}	169.1	126.7	147.9	0.80	36500	107730	71230	2.95	290.5	898.3	166.1
T_{13}	159.3	116.7	138.0	0.74	30900	110610	79710	3.57	290.5	1351	102.9
T_{14}	158.8	129.7	144.3	0.78	30900	106110	75210	3.43	290.5	1115	129.5
T_{15}	147.6	121.5	134.5	0.72	30900	98820	67920	3.19	290.5	898.3	150.0
SEd	9.34	6.30	6.02								
CD (p=0.05)	19.2	12.9	12.3								

CY: Crop yield (mean of 2 years); RCY: Ratoon crop yield (mean of 2 years); AY: Average yield (mean of 4 years); CY: Cost of cultivation (₹); GR: Gross return (₹ ha^{-1}); NR: Net return (₹ ha^{-1}); ER: Effective rainfall (mm); TWU: Total water used (mm); WUE: WUE (kg ha^{-1} mm^{-1})

treatment T_3 surface irrigation at 7 cm depth with 0.75 IW/CPE ratio (110.1 t ha^{-1}). Similar yield trend was observed in plant crop and ratoon crop. The yield ranged between 105.2 to 183.8 t ha^{-1} in plant crop and 106.1 to 145.8 t ha^{-1} in the ratoon crop. The similar increased yield trend with drip irrigation was reported by Selvaraj (1997) who stated that, in drip irrigation, water could be applied precisely and directly in the root zone with a water saving of 40-70% which in turn resulted in increased yield.

3.2. Economics

The results indicated that, highest B:C ratios of 4.17 and 4.10 were observed with surface irrigation at 5 and 7 cm depth with 1.00 IW/CPE ratio for wider row spacing (T_6 and T_7, respectively). Drip irrigation systems recorded the lowest B:C ratio values which could be ascribed to their initial high cost for the drip installation. The net returns obtained for various treatments showed that, the highest net returns of ₹ 83,650 ha^{-1} was obtained in drip irrigation once in two days at 60% PE for the wider row spaced sugarcane with one lateral row^{-1} (T_{11}) which might be due to the enhanced yield obtained from this treatment. The lowest net return of ₹ 59,872 ha^{-1} was realized in surface irrigation at 5 cm depth with 0.75 IW/CPE ratio in the conventional planting method (T_1). The cost of cultivation for the irrigation systems indicated that, the drip irrigation system required high initial cost hence the increased cost of cultivation. But the dual advantage of increased yield and water use efficiency may reduce the cost of cultivation in the subsequent years.

3.3. Water use efficiency

The total water used for surface irrigation treatments showed higher water consumption and the values ranged from 1068 to 1575 mm (Table 2). In drip methods, the lower water consumption was noted with 40% PE. The water use efficiency (WUE) data showed that, highest WUE values were observed with drip irrigation methods compared to the surface irrigation. The highest WUE of 166.1 kg ha^{-1} mm^{-1} was recorded with drip irrigation at 40% PE with one lateral row^{-1} for wider row spacing once in two days (T_{12}). The WUE in surface irrigation treatments ranged from 81.7 to 119.6 kg ha^{-1} mm^{-1}. The increase in water use efficiency in drip irrigation systems ranged to the tune of 10.6 to 73.8 kg ha^{-1} mm^{-1}. Increased water use efficiency might be due to reduced water utilisation and enhanced yield (Pawar et al. 1993, Chandia and Yaseen, 1995).

4. Conclusion

Drip irrigation at 60% PE with one lateral row^{-1} once in two days recorded the highest plant and ratoon cane yield besides registering the highest net return and WUE. The yield increase was 42.4 t ha^{-1} (25.7%) compared to conventional method with a water saving of 221 mm (16.5%). Hence the cost incurred on the drip system could be recovered in 2 years with the increased yield. Moreover with the saved water an additional area of 20% could be brought under irrigation and hence the payback period would be less than 2 years.

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