STUDIES ON DRIP IRRIGATION AND FERTIGATION IN SUGARCANE IN IRRIGATED NORTH WESTERN PLAIN ZONE OF RAJASTHAN

B.S.Yadav, A.S. Bhati, R.P.S.Chauhan and S.R. Bhuniya
AICRP on Water Management, Agricultural Research Station, Rajastha

ABSTRACT

The pooled data of three years revealed that the higher cane yield and tillers per square metre were recorded with single row planting than paired row planting. However, cane yield at 90x60 cm paired planting was at par with single row planting. Single row planting at 75 cm & 90 cm gave significantly higher commercial cane sugar (CCS) than paired row planting at 120x60 cm but at par with paired row planting at 90x60 cm. The highest cane yield and yield attributes were recorded with drip irrigation at 100% PE treatment, followed by 80 and 60 % PE treatments. The highest CCS in tones per hectare was recorded with drip irrigation at 100% PE which was at par with that obtained with drip irrigation at 80 % PE treatment. The juice percentage was also highest with 100 % PE treatment but poll percentage; brix percentage and CCS (%) were highest with 80 per cent PE treatment. The water use in surface irrigation and 100% PE treatment was almost equal but water use efficiency in 100% PE treatment was about 1.5 times higher than surface irrigation treatment in all the years. The highest WUE of was recorded with 60% PE treatment during all the three years.

The mean data revealed that drip irrigation at 60, 80 & 100 % PE increased cane yield by 14.4, 26.4 & 44.6 per cent, respectively over the cane yield obtained with border strip irrigation. In addition to yield increase, the respective water saving was 32.9, 17.1 & 1.4 per cent. Drip irrigation also improved the quality of cane and the commercial cane sugar increased by 46.4, 35.8 and 15.1 per cent as a result of drip irrigation at 60, 80 and 100% PE, respectively over that obtained with conventional flood irrigation treatment. The 75% recommended dose of N and K_2O in 9 equal splits at an interval of 20 days was found optimum for sugarcane.

INTRODUCTION

Sugarcane is the second commercial crop after cotton in irrigated North-Western Rajasthan. Its water requirement is the highest among the crops grown in this zone. This crop requires 1700 to 1900 mm water during its growth period. The timing of application of water as well as total water requirement both are the important factors influencing crop production. Sugarcane crop has adventitious root system. Its roots are deep and dense. About 18 to 21 irrigations are needed to the crop during its growth period depending on the amount and distribution of rainfall. The farmers of the zone grow sugarcane in limited area because of shortage of irrigation water. The Government provides additional water as an incentive to the sugarcane farmers to encourage its cultivation in the zone. The most common practice in the region is border strip method of irrigation. The micro irrigation techniques have a major role to play in mitigating the water scarcity situation by application of water directly in the root zone. Drip system is highly precise irrigation method applying water directly to the root zone. Precise application of irrigation water and fertigation to sugarcane may help improve the productivity of the crop. Nutrient use efficiency in fertigation increases as a result of controlled and regular application of fertilizers (1). The capacity of the proposed sugar factory to be established in Sriganganagar district is almost double than the existing factory. There is need to increase the production as well as productivity of sugarcane in the zone. To optimize the irrigation & fertigation schedule for sugarcane the present investigation was undertaken.

MATERIALS AND METHODS

A field experiment was conducted on sugarcane to find out optimum crop geometry & irrigation schedule through drip system at farmer's field in Gang canal command for three consecutive years from 2005-06 and 2007-08. The treatments comprising of 4 crop geometries (single row planting 75cm, single row planting 90cm, paired row planting 60 cm x 90 cm, paired row planting 60 cm x 120 cm) and 4 irrigation levels (60, 80 and

100% of PE by drip system on alternate day, and border strip irrigation at IW/CPE 1.0 & irrigation water depth 7.5 cm). The soil was sandy loam in texture, low in organic carbon (0.35%), medium in available P_2O_5 (42 kg/ha) and high in available K_2O (410 kg/ha). The pH (1:2) and EC (1:2) of the soil were 8.05 and 0.21 dS/m, respectively. A uniform basal dose of 50 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha was applied at planting. Rest N (100 kg/ha) was applied in 2 splits, one half each in May and June as top dressing. Sugarcane cv. CO 6617 was sown as the test crop. In paired planting drip line was placed between two lines and in single row planting, drip line was placed along each line. In paired planting, drip running time was double than single row planting to make the water application same per unit area in both the crop geometries.

The second field trial was conducted at Agricultural Research Station, Sriganganagar to find out optimum fertigation schedule for sugarcane during 2005-06 to 2007-08. In this trial 2 irrigation levels (Drip irrigation at 50+70% PE & 70+100% PE on alternate day), 3 fertilizer doses (75, 100 & 125% of recommended dose of N & K) & 2 split doses (9 splits at an interval of 20 days & 12 equal splits at an interval of 15 days) were tested in combination along with one control of flood irrigation & recommended practice of fertilizer application. The first irrigation level was applied in April & May and the second irrigation level was applied from June onwards in both the irrigation treatments. The fertilizer in control treatment in second experiment was applied as per schedule given for first experiment. The soil was sandy loam in texture, low in organic carbon (0.20 %), medium in available P_2O_5 (43 kg/ha) and high in available K_2O (320 kg/ha). The pH (1:2) and EC (1:2) of the soil were 8.2 and 0.22 dS/m, respectively. Phosphorus was applied through single super phosphate as basal dose by drilling at the time of sowing in all the treatments. Nitrogen through urea and potash through muriate of potash were applied in 9 & 12 splits as per treatment. Sugarcane variety Co 6617 was sown as the test crop.

RESULTS AND DISCUSSION

Effect of planting Geometry:
The pooled data of three years revealed that the crop geometry did not influence cane yield and yield attributes in surface irrigation, however in drip irrigation, tillers per square metre and cane yield were significantly influenced. The higher cane yield and tillers per square metre were recorded with single row planting than paired row planting. However, cane yield at 90x60 cm paired planting was at par with single row planting. None of the quality parameters was influenced by different crop geometries in surface irrigation treatment. Only commercial cane sugar was significantly influenced by different crop geometries in drip irrigation. Single row planting at 75 cm & 90 cm gave significantly higher CCS (t/ha) than paired row planting at 120x60 cm but at par with paired row planting at 90x60 cm. The crop geometry of 75-150 x 30 cm paired row planting was found optimum for suru sugarcane in deep black soils at Rahuri in Maharashtra (3).

Effect of drip Irrigation:
The different irrigation levels significantly influenced cane yield, tillers per square metre, cane length and inter node length (Table 1). The highest cane yield and yield attributes were recorded with drip irrigation at 100% PE treatment, followed by 80 and 60 % PE treatments. The lowest cane yield, tillers per square metre and internode's length was recorded with surface irrigation treatment. Drip irrigation also gave significantly higher cane yield and water use efficiency at Hisar in Haryana under semi-arid conditions (2).

Table 1: Effect of crop geometry and drip irrigation on cane yield and yield attributes (Pooled data of three years)

Treatment	Cane yield (t/ha)	Germination (%)	Tillers / sq. m	Cane length (m)	Inter node length (cm)	Cane girth (dia. in cm)
Crop geometry (surface)						
75 cm row spacing	91.21	46.54	20.06	2.31	13.87	2.32
90 cm row spacing	89.75	47.93	19.37	2.27	13.78	2.36
90cm X 60 cm paired row	88.15	49.80	19.05	2.11	13.83	2.32
120cm X 60 cm paired row	85.87	50.55	18.13	2.18	13.62	2.27
S. Em.±	5.53	2.52	1.38	0.07	0.54	0.06
CD at 5%	NS	NS	NS	0.27	NS	NS
Crop geometry (drip)						
75 cm row spacing	119.80	50.82	25.68	2.30	14.48	2.30
90 cm row spacing	117.46	50.82	25.95	2.33	14.97	2.40
90cm X 60 cm paired row	115.18	51.13	22.26	2.31	14.30	2.34
120cm X 60 cm paired row	103.62	49.13	21.53	2.27	14.19	2.33

S. Em.±	3.19	1.45	0.80	0.04	0.31	0.04
CD at 5%	9.21	NS	2.28	0.14	NS	NS
Irrigation levels						
IW/CPE 1.0	88.74	48.70	19.16	2.22	13.77	2.29
100% PE (drip)	128.29	50.43	25.92	2.39	15.27	2.39
80% PE (drip)	112.21	50.62	23.46	2.30	14.32	2.34
60% PE (drip)	101.54	50.88	22.19	2.21	13.87	2.30
S. Em.±	2.98	1.36	0.73	0.04	0.27	0.04
CD at 5%	8.62	NS	2.14	0.12	0.83	NS

Water use and Water use Efficiency:

In surface irrigation treatment, total 1790, 1572.9 and 1884.2 mm water was applied during 2005-06, 2006-07 and 2007-08, respectively. Water use efficiency was the highest with 75 cm row spacing during 2005-06 and 2006-07, whereas, during 2007-08 it was highest with 90 cm row spacing. The lowest WUE was recorded with 120cm x 60 cm paired row spacing during all the three years. In drip irrigation treatment, 1477.4, 1294.9 and 1575.2 mm average water was applied during 2005-06, 2006-07 and 2007-08, respectively (Table 2). The WUE was the highest in 75 cm row spacing during 2005-06 and 2007-08, whereas, during 2006-07 it was highest with 90 cm row spacing. In paired row crop WUE was lower as compared to single row crop.

There was considerable difference in water use and water use efficiency in different irrigation treatments. The water use in surface irrigation and 100% PE treatment was almost equal but water use efficiency in 100% PE treatment was about 1.5 times higher than surface irrigation treatment in all the years. Water use decreased constantly in 80 and 60 % PE treatments and accordingly water use efficiency increased. All the drip irrigation levels recorded higher WUE than surface irrigation treatment. The highest WUE of was recorded with 60% PE treatment during all the three years. In different crops in different parts of India, drip irrigation saved irrigation water to the extent of 60% with yield increase from 30-40 percent (4).

Table 2: Effect of crop geometry and drip irrigation on water use and water use efficiency

Treatment	**Water use (mm)***			**Water use efficiency (kg/ha mm)**		
	05-06	**06-07**	**07-08**	**05-06**	**06-07**	**07-08**
Crop geometry (Surface irrigation)						
75 cm row spacing	1790	1572.9	1884.2	55.20	67.89	36.10
90 cm row spacing	1790	1572.9	1884.2	54.02	65.99	37.83
90cm X 60 cm paired row	1790	1572.9	1884.2	52.65	66.61	33.44
120cm X 60 cm paired row	1790	1572.9	1884.2	51.96	64.75	33.31
Crop geometry (Drip irrigation)						
75 cm row spacing	1477.4	1294.9	1575.2	88.43	110.87	54.08
90 cm row spacing	1477.4	1294.9	1575.2	85.37	114.12	53.62
90cm X 60 cm paired row	1477.4	1294.9	1575.2	81.30	107.40	50.98
120cm X 60 cm paired row	1477.4	1294.9	1575.2	76.18	88.49	53.15
Surface & drip irrigation						
IW/CPE 1.0 (surface)	1790.0	1572.9	1884.2	53.46	66.14	35.17
100% PE(drip)	1793.0	1544.9	1835.4	79.05	97.79	50.16
80% PE(drip)	1477.4	1295.9	1575.2	83.49	100.61	52.62
60% PE(drip)	1161.8	1043.9	1315.0	87.79	121.93	57.28

*Including pre-sowing irrigation of 100 mm and rainfall of 115, 197.9 & 434.2 mm during 2005-06, 2006-07 & 2007-08, respectively.

Effect of drip irrigation on quality:

Irrigation levels significantly influenced all the quality parameters except juice purity percent (Table 3). The highest CCS in tones per hectare was recorded with drip irrigation at 100% PE which was at par with that obtained with drip irrigation at 80 % PE treatment but significantly higher than drip irrigation at 60% PE and surface irrigation treatments. The juice percentage was also highest with 100 % PE treatment but poll percentage; brix percentage and CCS (%) were highest with 80 per cent PE treatment. The commercial cane sugar increased by 46.4, 35.8 and 15.1 per cent as a result of drip irrigation at 60, 80 and 100% PE, respectively over that obtained with conventional flood irrigation treatment.

Table 3: Effect of crop geometry and drip irrigation on cane quality parameters (Pooled data of three years)

Treatment	CCS (t/ha)	Juice (%)	Baggase (%)	Poll (%)	Brix (%)	CCS (%)	Juice purity (%)
Crop geometry (surface)							
75 cm row spacing	9.30	35.90	64.10	14.36	16.39	9.99	87.45
90 cm row spacing	8.90	36.26	63.74	14.04	15.89	9.78	87.48
90cm X 60 cm paired row	8.69	36.32	63.68	13.97	16.16	9.67	86.32
120cm X 60 cm paired row	8.10	35.45	64.55	13.47	15.40	9.32	87.44
S. Em.+	0.80	1.25	1.25	0.49	0.53	0.42	2.44
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Crop geometry (drip)							
75 cm row spacing	12.11	37.32	62.68	14.22	16.75	9.89	85.09
90 cm row spacing	12.26	37.13	62.87	14.43	16.67	10.03	87.08
90 X 60 cm paired	11.51	38.02	61.98	14.55	16.53	9.92	86.64
120 X 60 cm paired	10.46	37.87	62.13	14.32	16.84	9.98	85.86
S. Em.+	0.46	0.72	0.72	0.48	0.30	0.25	1.41
CD at 5%	1.33	NS	NS	NS	NS	NS	NS
Irrigation levels							
IW/CPE 1.0	8.75	35.98	64.02	13.96	16.01	9.67	87.17
100% PE (drip)	12.81	38.60	61.40	14.24	16.58	9.77	85.81
80% PE (drip)	11.88	37.98	62.02	14.93	17.18	10.42	86.78
60% PE (drip)	10.07	36.18	63.82	14.03	16.33	9.68	85.88
S. Ed	0.40	0.64	0.64	0.25	0.26	0.21	1.16
CD at 5%	1.22	1.93	1.93	0.75	0.80	0.65	NS

Economics of drip irrigation:

The net income from surface irrigation treatment was Rs 57051.00 as against drip (electric) irrigation Rs. 67625.00. The additional net income in drip irrigation treatment due to 27% additional coverage of area was Rs. 18259.00. Thus, the net total income in drip irrigation treatment was Rs 85884.00. The benefit cost ratio under surface and drip irrigation treatments was 2.27 & 2.10, respectively (Table 4).

Table 4. Benefit cost analysis of drip system in sugarcane

Sr No.	Particulars	Method of Irrigation			
		Surface	Drip (Electric)	Drip (Diesel)	Drip (Electric +Subsidy)
1.	Fixed Cost (Rs.)	--	100000	100000	50000
	Life	--	15	15	15
	Depreciation (Rs/year)	--	6666	6666	3333
	Interest (12% yearly)	--	12000	12000	6000
	Maintenance & running cost	--	1550	14920	1550
2.	Cost of cultivation	45000	41200	41200	41200
3.	Total cost of cultivation (Rs/ha)	45000	61416	74786	52083
4.	Irrigation Water used (mm)	1400	1100	1100	1100
5.	Cane yield (q/ha)	887.4	1122.1	1122.1	1122.1
6.	Selling price (Rs/q)	115	115	115	115
7.	Return from produce (Rs)	102051	129041	129041	129041
8.	Net income (Rs)	57051	67625	54255	76958
9.	Add. Area cultiv. due to water saving	--	0.27	0.27	0.27
10.	Add. Expd. Due to add. Area cultiv (Rs)	--	16582	20192	14062
11.	Add. return due to add. Area (Rs)	--	34841	34841	34841
12	Additional net income (Rs)	--	18259	14649	20779
13.	Gross cost of production (Rs)	45000	77998	94978	66145
14.	Gross return (Rs)	102051	163882	163882	163882
15.	Net total income (Rs)	57051	85884	68904	97737
16.	Benefit cost ratio	2.27	2.10	1.73	2.48

Drip fertigation in sugarcane:

The pooled results of three years revealed that irrigation levels significantly influenced plant height, length of internode and cane yield (Table 5). Drip irrigation scheduled at 70+100% PE gave the maximum plant height, length of internode and cane yield. Drip irrigation scheduled at 50+70% and 70+100% PE increased cane yield over that obtained with conventional flood method of irrigation by 15.4 and 34.1 per cent, respectively. The respective drip irrigation treatments also saved irrigation water by 44.1 & 22.2 % over that used in flood irrigation treatment. Fertigation levels as well as fertigation splits did not influence cane yield and yield attributes. 75% recommended dose of N and K_2O was as effective as 100 and 125 % .Thus, 75% recommended dose of N and K_2O in 9 equal splits at an interval of 20 days has been recommended as fertigation schedule for sugarcane.

Table 5: Effect of levels and depth of irrigation on cane yield and yield attributes of sugarcane (Pooled mean of 3 years)

Treatments	Plant height (m)	No. of tillers/ 2m	Length of inter node (cm)	Diameter of inter node (cm)	Cane yield (q/ha)
Irrigation Levels					
I1 - 50% April & May & 70 % June onward of PE by drip system	1.75	26.67	12.17	2.41	586.42
I2 70% April & May & 100 % June onward of PE by drip system	1.91	28.42	13.59	2.46	680.95
Flood	1.70	26.89	11.95	2.35	507.82
S Em +	0.04	0.89	0.36	0.03	19.92
CD at 5%(Drip)	0.11	NS	1.03	NS	57.93
CD at 5%(Drip v/s Flood)	0.18	NS	1.34	NS	78.05
Fertilizer Dose (N & K)					
F1 - 75% of recommended	1.80	27.61	12.59	2.44	612.81
F2 -100% of recommended	1.83	27.14	12.77	2.42	620.21
F3 - 125% of recommended	1.86	27.89	13.28	2.46	668.03
S Em +	0.05	1.09	0.43	0.04	24.40
CD at 5%	NS	NS	NS	NS	NS
Time of fertilizer application (N&K)					
S1 - 9 Splits (21 days interval)	1.79	28.06	12.76	2.43	636.51
S2 - 12 Splits (15 days interval)	1.87	27.04	12.99	2.45	630.86
S Em +	0.04	0.89	0.36	0.03	19.92
CD at 5%	NS	NS	NS	NS	NS

REFERENCES

- Ashwani Kumar and Singh, A.K. 2002. Improving nutrient and water use efficiency through fertigation. Journal of Water Management **10** (1&2) : 42-48
- Dhindwal, A.S., Kumar, R. and Kumar S. 2005. Evaluation of drip and surface irrigation in sugarcane under semi-arid condition. Journal of Water Management. **13** (1) : 21-26
- Magar, S.S. and Nangude, S.B. 2005. Micro-irrigation status and holistic strategy for evergreen revolution. Journal of Water Management. **13** (2) : 106-111
- Mahadkar, U.V., Shinde, J.B., Pawar, D.D., Raut, R.S., Kolekar, P.T. and Gaikwad, C.B. 2005. Effect of planting geometry and intercrops on suru sugarcane under drip irrigation. Journal of Water Management. **13** (1) : 16-20