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Effect of saline water irrigation on soil properties and yield and quality of sugarcane (*Saccharum officinarum*)*

B S GHUMAN[1], O P CHOUDHARY[2], R S SINGH[3], KULDIP SINGH[4], J S BRAR[5], ANGREJ SINGH[6] and G S DHALIWAL[7]

Punjab Agricultural University, Ludhiana, Punjab 141 004

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Sugarcane (*Saccharum officinarum*), an important cash crop, requires assured irrigation in arid and semi-arid regions (Choudhary *et al*. 2004). Due to inadequate availability of good quality surface water in these areas, farmers have to use poor quality ground waters for irrigation. In Punjab, about 41% of ground waters are brackish majority of which are concentrated in south-western districts (Choudhary and Ghuman 2008). Response of different sugarcane cultivars to saline water irrigation and its cyclic use with canal water has not been studied adequately. Singh *et al*. (2007) reported the influence of saline water irrigation on sugarcane. But they did not study the effect of irrigation with saline water applied in a cycle with canal water. Such situations may arise at the tail end of some canal commands due to limited canal water supplies.

A field investigation was carried out during 2005–08 to study the effect of saline water irrigation on soil properties, yield and quality of 3 sugarcane cultivars at Regional Station (PAU), Faridkot (30° 67'N latitude; 74° 75'E longitude and 201 m amsl), south-west Punjab. Soil was non-saline loam having *p*H (1 : 2 soil water) 8.6, electrical conductivity 0.36 dS/m and organic carbon 4.0 g/kg. Underground water was saline having EC of 3.2–3.5 dS/m. Sugarcane cultivar 'CoJ 88' was planted in 2005 in plots measuring 5.5 m × 6.5 m each. Two more cultivars 'CoJ 83' and 'CoJ 89' were included in 2006. Treatments were irrigation with canal water (CW), saline water (SW), saline water used in conjunction with canal water in different cycles (CW/SW, 2CW/SW, SW/CW, 2SW/CW) and saline water irrigated plots receiving farmyard manure @ 20 Mg/ha at sugarcane planting. Recommended package of practices were used for raising the crop. Irrigation treatments were imposed after planting. Planted crop of sugarcane was taken in 2005–07 and ratoon crop in 2007–08.

Irrigation (75 mm in depth) was given when an equivalent depth of water evaporated from evaporimeter. Rainfall received during the growth period of sugarcane was 418, 576 and 434 mm in 2005–06, 2006–07 and 2007–08, respectively. At harvest, sugarcane yield was recorded after topping and stripping the cane of trash. At harvest of the third crop, soil *p*H, EC, bulk density and infiltration rate were determined following standard methods (Richard 1954, Page 1986). Juice quality parameters (brix and% sucrose) were used to compute commercial cane sugar (CCS). The data was analyzed using split-plot design (Little and Hills 1978).

After 3 years of cropping, bulk density in the 0–5 and 5–10 cm soil layers was significantly lower in saline water compared to canal water treatment (Table 1). When saline water was applied with canal water in a cyclic mode, bulk density in these soil layers increased and was comparable to that under canal water. Application of farmyard manure under saline water treatment also increased the bulk density compared to saline water alone treatment. Bulk density of the 10–15 cm soil layer was not affected significantly. Infiltration rate increased by 50% in plots under saline water compared to that under canal water irrigation (Table 1). Application of farmyard manure resulted an increase in infiltration rate from 4 mm/hr in April 2005 to 6 mm/hr in February 2008. Decrease in bulk density and increase in infiltration rate occurred due to addition of root biomass of the crop, particularly when soil was left undisturbed in ratoon crop. Higher electrolytes added through saline water irrigation might also have increased flocculation of soil particles.

Mean soil *p*H and EC at the end of 3 years were significantly influenced by irrigation treatments (Table 1). Soil *p*H in the 0–15 cm layer under canal water irrigation

*Short note

[1]Senior Soil Physicist, [2]Senior Soil Chemist, [6,7]Research Fellows, Department of Soils, [3]Sugarcane Breeder, [4]Agronomist, Regional Station (PAU), Faridkot 151 203;

[3]Senior Extension Specialist, FASS (PAU), Bathinda 151 001

Table 1 Effect of saline water irrigation on bulk density, steady- state infiltration rate, soil *p*H and soil EC after 3 years of sugarcane cropping

Treatment	Bulk density (Mg/m^3) in layer			Infiltration rate (mm/hr)	Soil *p*H		Soil EC (dS/m)	
	0–5	5–10	10–15 (cm)	January 2008	0–15 (cm)	15–30 (cm)	0–15 (cm)	15–30 (cm)
CW[#]	1.35	1.40	1.42	4	8.76	8.85	0.50	0.40
SW	1.12	1.28	1.32	6	8.91	9.00	0.65	0.55
CW/SW	1.31	1.44	1.38	4	8.87	8.92	0.53	0.41
2CW/SW	1.37	1.44	1.39	4	8.85	8.94	0.67	0.53
SW/CW	1.23	1.37	1.34	4	8.74	8.84	0.71	0.63
2SW/CW	1.23	1.43	1.50	4	8.83	8.93	0.51	0.46
SW+FYM	1.26	1.33	1.36	6	8.75	8.85	0.66	0.54
LSD (0.05)	0.21	0.18	NS	1	0.11	0.09	0.10	0.10

[#]CW, Canal water; SW, saline water; FYM, farmyard manure

was 8.76 and increased to 8.91 in plots irrigated with saline water. Soil *p*H in treatments receiving saline water and canal water in cyclic modes ranged between these two values. The trend was similar in the 15–30 cm layer. Mean soil EC increased significantly from 0.50 to 0.65 dS/m in the 0–15 cm layer and from 0.40 to 0.55 dS/m in the 15–30 cm layer when plots were irrigated with saline water instead of canal water (Table 1).

Sugarcane yield in 2006–07 was significantly influenced by irrigation treatments (Table 2). Mean cane yield was 28% lower under saline water irrigation. Decrease in cane yield under saline water treatment can be attributed to the higher EC (3.2–3.5 dS/m) of saline water than the threshold level of EC (1.7 dS/m) for sugarcane (Choudhary *et al*. 2004). Cyclic mode of irrigation increased mean cane yield by 10% in SW/CW, by 3% in 2SW/CW, by 13% in CW/SW and by 23% in 2CW/SW compared to saline water treatment. It suggests that occasionally irrigation cycle can be started with saline water, particularly when canal water is not available at sugarcane planting. Results across cultivars indicated that cultivar 'CoJ 88' yielded significantly higher than 'CoJ 83' and 'CoJ 89'. Cultivar 'CoJ 88' gave 88 tonnes/ha yield under saline water that was closer to the yields of 'CoJ 83' (84.0 tonnes/ha) and 'CoJ 89' (91 tonnes/ha) obtained under canal water irrigation. This cultivar also responded better to the management interventions (cyclic use and application of farmyard manure) than the other 2 cultivars. These results suggest that 'CoJ 88' was relatively more tolerant than the other 2 cultivars to salinity. Probably the tolerant cultivar had the ability to exclude Na^+ and Cl^- as reported by Huwyzeh *et al.* (2008).

Relative to canal water irrigation, per cent commercial cane sugar was significantly reduced in 3 cultivars under saline water irrigation (Table 2). The extent of decrease in per cent commercial cane sugar was less in cultivar 'CoJ 88' (11%) compared with the other 2 cultivars (17–18%). When saline water and canal water were used in different cyclic modes, per cent commercial cane sugar increased over saline

Table 2 Effect of saline water irrigation on sugarcane yield and per cent commercial cane sugar (%CCS)

Treatment	'CoJ 83'	'CoJ 88'	'CoJ 89'	Mean
Cane yield (*tonnes/ha*), *second crop, planted* (*2006–07*)				
CW[#]	84.0	112.0	91.0	95.7
SW	57.0	88.0	63.0	69.3
CW/SW	61.0	102.0	72.0	78.3
2CW/SW	68.0	109.0	79.0	85.3
SW/CW	63.3	96.0	69.0	76.1
2SW/CW	59.0	91.0	63.7	71.2
SW+FYM	82.3	108.0	87.0	92.4
Mean	67.8	100.8	74.9	
LSD (0.05) Treatment = 2.8; Cultivar = 1.7; Interaction = 4.9				
Cane yield (*tonnes/ha*), *third crop, ratoon* (*2007–08*)				
CW	73.5	100.0	80.3	84.6
SW	47.4	81.6	52.1	60.4
CW/SW	50.6	91.6	65.8	69.4
2CW/SW	58.1	99.1	69.3	75.5
SW/CW	53.0	86.5	59.6	66.4
2SW/CW	49.3	81.3	54.6	61.8
SW+FYM	71.3	98.1	77.0	82.2
Mean	57.6	91.2	65.5	
LSD (0.05) Treatment = 3.9; Cultivar = 3.8; Interaction = 6.7				
% CCS (*2007–08*)				
CW	11.07	11.15	11.07	11.10
SW	9.13	9.93	9.08	9.38
CW/SW	9.44	10.47	9.78	9.90
2CW/SW	9.84	10.66	10.07	10.19
SW/CW	9.35	10.48	9.66	9.83
2SW/CW	9.22	10.09	9.33	9.55
SW+FYM	10.69	10.97	10.86	10.84
Mean	9.82	10.54	9.98	
LSD (0.05) Treatment = 0.47; Cultivar = 0.29; Interaction = NS				

[#]CW, Canal water; SW, saline water; % CCS, [% sucrose – (brix – % sucrose) × 0.4] × 0.63

water irrigation. Application of farmyard manure with saline water irrigation significantly improved per cent commercial cane sugar (10.7%). Among the cultivars, 'CoJ 88' again had significantly higher mean per cent commercial cane sugar than 'CoJ 83' and 'CoJ 89'. The differences in cultivars and irrigation treatments became pronounced in case of sugar yield in 2007–08. Under saline water treatment, cultivar 'CoJ 88' had 86 and 72% higher sugar yield than 'CoJ 83' and 'CoJ 89', respectively.

SUMMARY

A field experiment was conducted during 2005–08 to evaluate the effect of saline water (EC 3.2–3.5 dS/m) irrigation on soil properties and performance of 3 cultivars of sugarcane ('CoJ 83', 'CoJ 88', 'CoJ 89'). Treatments included irrigation with canal water (CW), with saline water (SW), with SW and CW applied in different cyclic modes (CW/SW, 2CW/SW, SW/CW and 2SW/CW) and application of farmyard manure to soil under saline water irrigation. Irrigation with saline water for 3 years decreased soil bulk density, and increased infiltration rate, *p*H and electrical conductivity relative to canal water treatment. Irrigation with saline water significantly decreased cane yield. Compared to saline water treatment, cyclic use of saline water with canal water increased cane yield ranging from 3% in 2SW/CW to 23% in 2CW/SW treatment in 2006–07. Application of farmyard manure under saline water irrigation improved cane yield by 34% over saline water. Among the cultivars 'CoJ 88' significantly out yielded 'CoJ 83' and 'CoJ 89'. Performance of 'CoJ 88' in ratoon crop (2007–08) was even better than the other two cultivars. Cultivar 'CoJ 88' also had the highest mean value of commercial cane sugar (10.5%) than the other 2 cultivars. In situations where canal water is not available at the time of planting, cane and thus sugar productivity can be sustained at higher levels with 'CoJ 88' cultivar using saline water in cyclic mode with canal water or in farmyard manure-amended soil. Therefore, we recommend growing of sugarcane cultivar 'CoJ 88' in areas inflicted with saline groundwaters.

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