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Performance of sugarcane under distillery effluent application of sugar industries

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ABSTRACT

An experiment was conducted during 2006–07 at Dhenkanal, Orissa to assess the effect of distillery effluents of sugar industries on sugarcane growth, yield, juice quality and relevant soil physico-chemical properties. Application of nutrient enriched distillery effluents without dilution affected plant growth parameters [(plant height (2.5 m), number of leaves/cane (5.3), number of tillers/hill (4.3) at harvest; yield (42.7 tonnes/ha) and quality of cane juice (*p*H 5.6, EC 10.6 dS/m, specific gravity 1.096 g/cm^3, Brix 21.1%, Polarity 17.2%)] at significant level, but improved these parameters when combined with freshwater at various levels. Alternate application of distillery effluent and freshwater gave the highest cane yield (133.8 tonne/ha) with sugar concentration (18.5 tonnes/ha). It also improved other growth parameters, nutrient contents and overall fertility status of soil. Plant nutrient loaded distillery effluent of sugar industries with high organic matter (soluble) content is thus proved a good irrigation source and soil amendment.

Key words: Distillery effluent, Good irrigation source, Soil amendments, Sugarcane, Sugar industries

In India sugarcane is grown in 3.62 million ha area, out of which 84.1% is irrigated. It is a long-duration, water- and nutrients-exhaustive crop. Irrigation water and inorganic fertilizer are being costly day by day hence there is a need to use water judiciously and nutrient management practices in situ (Rosabal *et al.* 2007, Keating *et al*. 1997). Distillery effluent has been used in past on wide array of crops considering their beneficial effect on soil health and improving crop yields (Rajeshwari *et al.* 2007, Biswas *et al.* 2009)

Distillery effluent of Sakthi Sugars Limited, Dhenkanal, is rich in major and minor plant nutrients (NO_3 – N, 819.6 mg/litre; P, 121.6 mg/litre; K, 2649 mg/litre; Ca, 1519 mg/litre; Mg, 700 mg/litre; Zn, 3.6 mg/litre; Cu, 8.1 mg/litre; Fe, 87.4 mg/litre and Mn, 9.4 mg/litre). It is neutral (*p*H 7), containing 0.87% organic carbon, 32 g/litre total dissolved solids and 33.5 g/litre total suspended solids. Use of such enriched byproduct of sugar industries could promote crop yield without any adverse impact on soil health if crop-specific dilution is maintained and managed for a particular environment (Jagdale and Savant 1979). However, the effect varies from place to place, depending on soil type, nature of crop and the application practice. The unfavourable impact of the effluent on crop growth and soil properties has also reckoned in several places. But as the effluent is endowed with crop beneficial constituents, underutilized and available at a great extent, a field study was therefore carried out to evaluate the impact of distillery effluent on growth performance, yield, juice quality of sugarcane and important soil properties.

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MATERIALS AND METHODS

An experiment was carried out in the field of Sakthi Sugars Limited, Dhenkanal, Orissa, during 2006–07 growing sugarcane as test crop. The soil was sandy loam, acidic in reaction, low in organic carbon, available N, P and K (Table 1). 'Co 86032' sugarcane was planted on 19 January 2006 in furrow with a spacing of 70 cm×50 cm and harvested on 15 January 2007.

Treated distillery effluent of Sakthi Sugars Limited was applied through 5 treatments. Experiment design was randomized block with 3 replications. Freshwater was applied by extending pipe into experimental plot at 30 mm crop evapotranspiration. Similarly, distillery effluent was also supplied by another pipe at different proportions as per treatment schedule. The crop evapotranspiration was computed daily using Hargreaves – reference ETo (Hargraves and Samani 1985), with daily meteorological data from Sakthi Sugars observatory, and crop co-efficient (Allen *et. al.* 1998) at different crop growth stages.

ET estimation

$$ET_0 = 0.0023\ R_a\ (TC + 17.8)\ TR^{0.50}$$

Where R_a, extra terrestrial radiation (mm/day);TR,Tmax.-

Table 1 Important soil properties after sugarcane harvesting

Treatment	pH_2	EC_2 (dS/m)	Org. C (%)	Humus C (%)	Available N (mg/kg)	Available P (mg/kg)	1N NH_4OAc – extractable (mg/kg)			DTPA–extractable (mg/kg)			
							K	Ca	Mg	Zn	Cu	Fe	Mn
Initial	5.60		0.55	0.10	200.11	21.18	144.00	259.72	320.68	4.58	6.14	15.28	191.74
Water	6.11	0.10	0.65	0.28	259.78	62.65	119.00	420.34	1171.62	2.80	3.75	45.78	87.62
50 (water)/50 (distillery effluent)	6.48	0.30	0.96	0.50	223.63	66.69	219.00	944.13	1208.23	3.76	4.59	37.76	72.56
Alternate distillery effluent/water	6.36	0.50	0.97	0.72	260.80	96.96	240.90	869.13	1391.30	3.73	2.56	20.36	50.62
40 : 60 (distillery effluent: water)	6.42	0.10	0.76	0.42	223.63	94.28	262.80	879.01	1208.23	3.74	5.52	44.30	75.06
Distillery effluent	6.64	0.80	0.69	0.28	194.26	95.36	350.40	1123.02	1464.52	2.48	3.42	87.43	59.06
SD	0.19	0.30	0.15	0.18	28.13	16.99	54.53	259.41	130.48	0.62	1.13	24.69	14.43
SE	0.09	0.13	0.07	0.08	12.58	7.60	24.39	116.01	58.35	0.28	0.51	11.94	6.45

Tmin.(°C);TC,Mean temperature (°C);ET crop= kc×ETo

In distillery-effluent treatment, 30 mm depth of pure distillery effluent was applied as per crop evapotranspiration and in remaining treatments, it was applied following a pre-designed dilution ratio (distillery effluent + water, @ 40: 60, 50: 50, and distillery effluent/freshwater alternatively). To evaluate the treatment effect on sugarcane, periodic biometric observations on plant height, leaves, tillers, number of internodes and juice quality, e g *p*H, electrical conductivity, specific gravity, brix value, polarity and purity percentage was recorded. Cane yield was partitioned to shoot, juice and trash by taking samples on 25 November 2006, 18 December 2006 and 4 January 2007 before harvest. On the basis of brix, purity and polarity (Pol) of juice, commercial cane sugar (CCS) per cent was calculated.

RESULTS AND DISCUSSION

Irrigation requirement

During crop period 80.1 cm irrigation was applied excluding 101.08 cm rainfall. Crop ET (estimated by Hargreave method) was 142.53 cm. Maximum amount of rainfall received in August and September had become non-effective as crop ET in the period was less than rainfall received. Alternate application of distillery effluent and water saved 50.6% irrigation water without any adverse effect on cane yield, while in other treatments the saving was in a range of 38.2 to 47.8 (Table 3).

Crop growth response

Tiller number, functional leaves and plant height were significantly enhanced by distillery effluent application with or without combination of freshwater and recorded highest

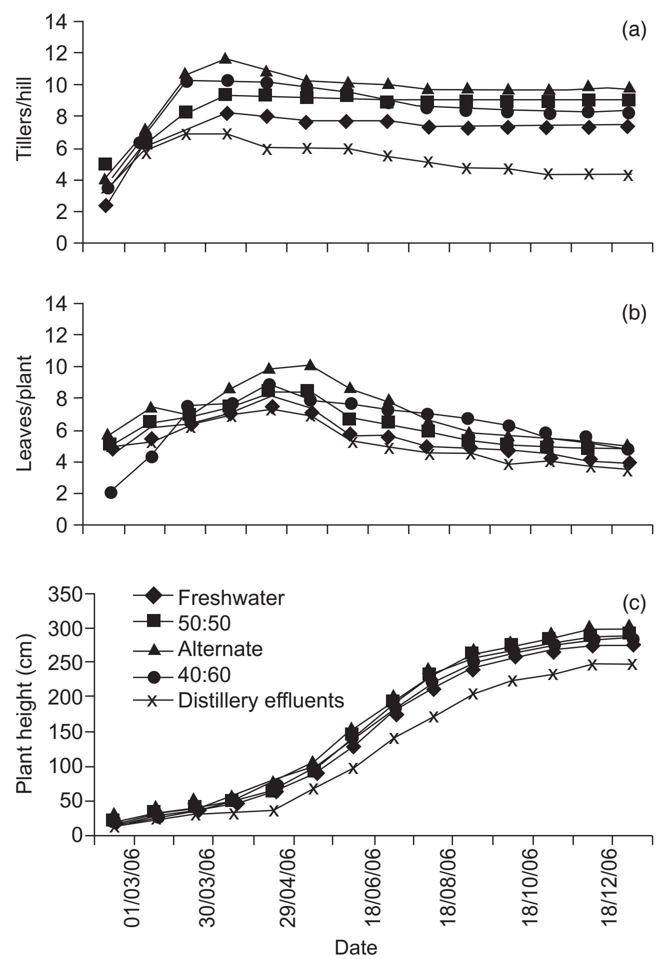

Fig 1. Number of tillers/hill (a), leaves/plant (b), and plant height (c) as affected by distillery effluents

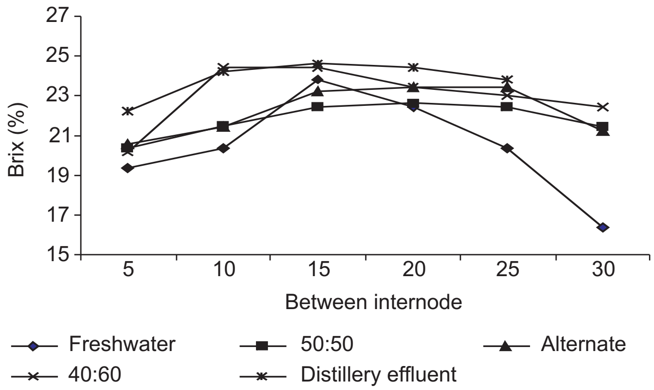

Fig 2 Brix value on 4.1.2007 (before harvest)under different proportion of distillery efflunt application in sugarcane

under alternate use of distillery effluent and water. Plant growth rate was higher in all treatments during formative stages (first 4 months after planting), remained static thereafter except in distillery effluent alone, where wilting started and plant mortality occurred. Functional leaves (number)/plant was increased till May 14, 2006, then the bottom leaves started drying, dried leaves were removed, new leaves were coming out and the process continued till harvest.

Trend of Brix value

Brix value measured at 5, 10, 15, 20, 25 and 30th inter-node position from plant bottom *in situ,* by portable refractometer to test the level of sucrose in cane juice as a sign of maturity before harvest. As per internode positions from top or bottom, the value changed per plant and varied with the treatments. But overall a lowest value was observed with freshwater treatment. Sucrose accumulation at 10 and 25th inter-node was highest among all (Fig 2). Translocation of photosynthates from top to bottom resulted low distribution of sucrose in the upper portion while continuous absorption of water from soil contributed relatively low sucrose at lower portion of the plant (Paul Sebastian *et al.*2009). These may attribute to high sucrose content at middle part of the plant.

Partitioning of cane yield

The juice volume was 43 to 61.1% in November and 47.3 to 65.9% in December 2006 with maximum at freshwater and minimum at distillery effluent (without dilution) treated plots. This indicates a shift of photosynthetic material from source to sink with age of the plant. Overall the juice volume was highest and trash was lowest under freshwater and a reverse was true in distillery effluent irrigation alone (Fig 3). The proportion of juice ranged from 58.7 to 65% and trash from 28.9 to 30.2% in rest of the treatments. Owing to comparatively higher growth rate, the shoot portion was also highest under freshwater treatment.

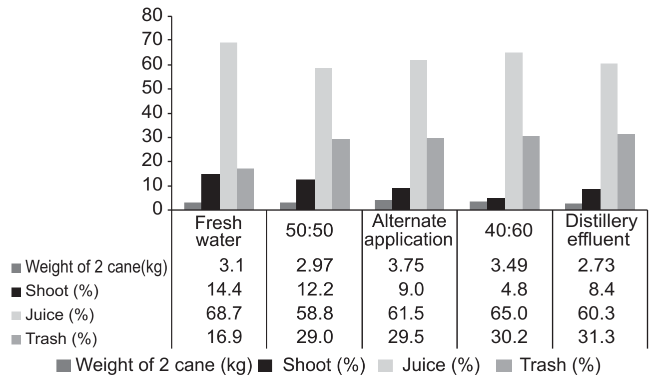

Fig 3. Weight of two canes and its distribution in juice, trash and shoot under different treatment

Cane yield and juice quality

Use of distillery effluent and freshwater irrigation at alternate interval, gave highest cane yield (133.8 tonnes/ha) against 84.65 tonnes/ha under freshwater irrigation as normal practice. Application of distillery effluent and freshwater at 50 : 50 and 40 : 60 ratios produced slightly lower yield but significantly lower with distillery effluent alone over freshwater treatment (Table 2). Under continuous application of distillery effluent, cane yield was 49.5% low over freshwater irrigation. Sugar yield was modified by 65% (18.54 tonnes/ha) more under alternate irrigation of distillery effluent with water than water alone. It significantly reduced to 6.30 tonnes/ha under distillery effluent alone in comparison

Table 2 Effect of effluent treatments on yield and quality of sugarcane

Treatment	Sugarcane yield (tonnes/ha)	Sugar yield (tonnes/ha)	CCS (%)	Brix (%)	Polarity (%)	Purity (%)	Juice quality attributes		
							*p*H	EC (dS/m)	Sp. gravity (g/cm^3)
Freshwater	84.65	11.23	13.27	18.61	16.30	79.27	5.31	5.9	1.049
50 : 50 (distillery effluent : water)	120.85	16.64	13.78	19.45	16.77	84.28	5.24	8.9	1.064
Alternate distillery effluent and water	133.77	18.54	13.87	19.90	16.38	82.06	5.20	9.8	1.080
40 : 60 (distillery effluent : water)	118.82	16.90	14.22	20.61	16.48	78.61	5.22	10.1	1.081
Distillery effluent	42.72	6.30	14.69	21.14	17.24	81.99	5.60	10.6	1.096
CD (P<0.05)	14.17	2.12	0.44	0.69	0.85	1.45	o.117	0.16	0.0275
CV (%)	7.50	8.8	1.93	1.85	2.71	0.95	8.044	15.08	12.5

Table 3 Treatment-wise account of irrigation amount applied during crop period

Month	Fresh water (cm)	50 : 50 distillery effluent : water (cm)		Alternate distillery effluent with water (cm)		40: 60 distillery effluent : water (cm)		Distillery effluent (cm)	Rainfall received (cm)
		Water	Distillery effluent	Water	Distillery effluent	Water	Distillery effluent		
January 19 to 31, 06	3.6	3.6	0	3.6	0	0	3.6	0	3.9
February 06	4.5	2.25	2.25	0	4.5	1.8	2.7	4.5	0
March 06	18	9	9	9	9	7.2	10.8	18	0
April 06	22.5	11.25	11.25	13.5	9	9	13.5	22.5	0.44
May 06	4.50	2.25	2.25	0	4.5	1.8	2.7	4.5	10.14
June 06	9.00	4.50	4.50	4.5	4.5	3.6	5.4	9	7.7
July 06	4.5	2.25	2.25	4.5	0	1.8	2.7	5	20.8
August 06	0	0	0	0	0	0	0	0	41.5
September 06	0	0	0	0	0	0	0	0	13.2
October 06	4.5	2.25	2.25	0	4.5	1.8	2.70	4.5	2.7
November 06	4.5	2.25	2.25	4.5	0	1.8	2.70	4.50	0.7
December 06	4.5	2.25	2.25	0	4.5	1.8	2.70	4.50	0
January 07	0	0	0	0	0	0	0	0	0
Total	80.1	41.85	38.25	39.6	40.5	30.6	49.5	77.0	101.08

to 11.23 tonnes/ha as obtained with freshwater irrigation. But Brix and Polarity values were relatively higher under distillery effluent irrigation. In one of the experiments in Tamil Nadu, Pushavalli *et al.* (2002) have reported maximum sugarcane yield of 170 tonnes/ha under 1: 30 as distillery effluent : water ratio that decreased with further increase of dilution ratio. In respect of improvement of soil physical and chemical parameters Bose *et al.* (2002) have observed a significant improvement on organic carbon, nitrogen, potassium, calcium, magnesium and micronutrients over control plot and opined that the enrichment might contributed to higher crop growth and yield under distillery effluent treated plots. From their experiment application of distillery effluent @ 3.75 lakh litres/ha has come up as best dose for sugarcane.

Excess application of nitrogen generally increases immature suckers, promotes vegetative growth till maturity, binds sugars with nitrogenous compound and then produces undesirable sugar. Singh and Mohan (1994) have recorded poor quality of juice, increased enzymes activities, degrades sugar when the crop was fertilized beyond 300 kg N/ha. Fritz (1974) and Wiedenfeld (1995) reported that during ripening phase, abundance of nitrogen in plant reduces sucrose accumulation. This may explain the reduced cane growth, yield and sugar per cent under highly concentrated distillery effluent irrigation treatment. A significant decline in juice quality (EC, *p*H, specific gravity) was also evident with distillery effluent over other treatments (Table 2).

Improvement in soil properties

Application of distillery effluent improved chemical properties of soil with respect to all major and secondary nutrients. No improvement in micronutrients was evident except Fe which enhanced by 25 to 82% over initial concentration (Table 2). The magnitude of improvement varies with DE volume, applied at each irrigation cycle. In case of distillery effluent-treated plot, available nitrogen was rather low as compared to initial content, but improved in remaining treatments. A substantial increase in other nutrients due to application of distillery effluent was evident (Table 1). Some workers have reported increased available nitrogen, phosphorus and potassium in effluent-treated plots from 1 : 10 to 1 : 30 as dilution of distillery effluent: water but decreased with further dilution over the initial concentration of respective elements (Anandakrishnan *et al.* 2007 Chidankuma *et al.* 2009, Pushavalli *et al*. 2002).

Distillery effluent of sugar industries has come up as nutrient-enriched irrigation source. Alternate use of it with freshwater has found optimum for producing highest cane yield and juice per cent without imparting any harmful impact on soil properties. It can save a sizeable amount of freshwater without loss of cane productivity growing under water-deficient upland and medium land situations. This way the industrial wastewater could be utilized without burdening of the environment.

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