Indian Journal of Agronomy **50** (3) : 239–242 (September 2005)

Irrigation management for sustainable cane production

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Received : May 2004

ABSTRACT

An experiment was conducted during 1998–99 and 1999–2000 to standardize the methods of irrigation with and without trash mulching. All furrow irrigation positively influenced all yield attributes and nutrient uptake and appreciably increased the cane yield. It was comparable with alternate furrow irrigation with trash mulching. The cane growth as well as cane production was reduced under skip furrow irrigation with or without trash mulching. Since the combination of trash mulching with all furrow and alternate furrow irrigation recorded comparable values for cane yield, it could be possible to economize the use of irrigation water to the tune of 41% by following alternate furrow irrigation during the formative phase of sugarcane. It also recorded the highest water-use efficiency, energy-use efficiency and productivity, indicating the effective and efficient utilization of resources with better conservation.

Key words : All furrow, Alternate furrow, Skip furrow, Trash mulching, Cane Yield

Sugarcane being a long-duration crop requires constant supply of moisture during the entire period of growth. In Kerala, the crop is irrigated with river water in deltaic region and from groundwater in the semi-arid tracts for a period of 5 to 6 months. Water stress during the formative phase affects the yield drastically. Adoption of water-conservation practices like mulching and improved methods economizes the use of irrigation water without compromise in crop yieids. Hence present study was undertaken to standardize the methods of irrigation with and without trash mulching and to determine its influence on yield attributes, cane yield and utilization of resources.

MATERIALS AND METHODS

The experiment was laid out in factorial randomized block design during the crop season of 1998–99 and 1999–2000 at Sugarcane Research Station, Thiruvalla. The treatments consisted of 8 combinations of 4 methods of irrigation and 2 mulching practices with 3 replications. The methods of irrigation were all furrow irrigation (I_1), alternate furrow irrigation (I_2), skip furrow irrigation (I_3) and farmer's practice (I_4); and mulching treatments were no mulching (M_o) and trash mulching at 5 tonnes/ha (M_1). Irrigation was scheduled at fortnightly interval in all, alternate and skip furrow irrigation. While in farmer's practice, it was scheduled once in a month. The depth of irrigation was 5 cm. The soil was Entisol and acidic in reaction (pH 5.4), medium in available nitrogen (140 ppm) and available potassium (37.5 ppm) and low in available phosphorus (3.02 ppm). The test variety was 'Madhuri'. The trash, greentops and stem collected at harvest through destructive sampling were used for dry-matter production and chemical analysis of N, P, K, Ca, Na, Fe, Mn, Zn and Cu (Jackson, 1973). Irrigation water-use efficiency (WUE) was worked out based on the cane yield and total depth of irrigation water used during the formative phase. Energy-use efficiency and productivity were also worked out (Pal *et al.*, 1985). The crop was raised as per package of practices recommendation.

RESULTS AND DISCUSSION

Effect of irrigation

The treatment variations due to methods of irrigation were significant for yield attributes, cane yield, nutrient uptake, water-use efficiency (WUE), energy-use efficiency and energy productivity (Tables 1, 2). Among the methods of irrigation, all furrow irrigation (I_1) invariably showed its superiority in respect of number of millable canes, cane length, cane weight, total uptake of N, P, K, Fe, Mn, Zn, Cu and resulted in the highest the cane yield compared to other irrigation-management practices. It was closely followed by alternate furrow irrigation (I_2). The beneficial effect of all furrow irrigation over alternate furrow irrigation was only 2.65%. Farmers' practice (I_4) invariably decreased all yield parameters, uptake of major nutrients, micronutrients and resulted in lower yield. Alter-

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Table 1. Effect of methods of irrigation and trash mulching on yield attributes, cane yield, water-use efficiency and energetics of sugarcane

Treatment	Cane length (cm)		Cane girth (cm)		Single cane weight (g)		Millable cane count ('000)		Cane yield (tonnes/ha)		WUE (tonnes/ha-cm)		Energy productivity (g/MJ)		Energy-use efficiency	
	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop
I_1	252	254	9.5	9.0	1,133	1,121	98.82	100.43	104.32	106.05	1.73	1.76	1,483	1,587	10.07	10.61
I_2	249	250	9.4	9.5	1,113	1,115	97.09	97.96	101.6	103.20	2.33	2.42	1,569	1,613	10.71	11.05
I_3	232	235	9.1	9.2	1,031	1,039	91.23	90.24	89.37	90.49	2.11	2.12	1,392	1,414	9.08	9.59
I_4	232	240	9.1	9.2	1,028	1,052	91.6	91.54	90.86	92.09	2.25	2.30	1,343	1,395	8.74	9.33
CD (P=0.05)	5.63**	5.33**	0.09**	0.14**	20.88**	6.73**	1.57**	1.54**	1.23**	2.04**	0.04**	0.03**	18.00**	30.00**	0.26**	0.26**
M_0	237	242	9.2	9.3	1,058	1,069	92.96	92.43	93.58	95.03	2.05	2.09	1,421	1,520	9.40	9.90
M_1	245	248	9.4	9.5	1,093	1,094	96.45	97.65	99.53	100.89	2.18	2.21	1,473	1,555	9.90	10.40
CD (P=0.05)	3.98**	3.77**	0.06**	0.10**	14.76**	4.76**	1.11**	1.10**	0.87**	1.44**	0.03**	0.02**	1,800	21.00**	0.19**	0.19**
I_1M_0	249	281	9.5	9.6	1,119	1,116	97.15	98.14	101.23	103.33	1.68	1.71	1,457	1,410	9.84	10.40
I_1M_1	254	257	9.6	9.6	1,148	1,127	100.49	102.71	107.40	108.76	1.28	1.81	1,509	1,444	10.30	10.83
I_2M_0	244	246	9.3	9.4	1,080	1,105	95.06	94.44	96.54	98.14	2.26	2.30	1,511	1,444	10.17	10.64
I_2M_1	253	255	9.6	9.6	1,145	1,126	99.13	101.48	106.79	108.27	2.50	2.54	1,628	1,670	11.26	11.47
I_3M_0	226	229	8.9	9.1	1,015	1,024	89.50	88.02	87.53	88.39	2.05	2.01	1,370	1,401	8.87	9.28
I_3M_1	238	240	9.3	9.3	1,147	1,053	92.96	92.47	91.22	92.59	2.17	2.17	1,413	1,428	9.28	9.90
I_4M_0	228	240	9.0	9.1	1,017	1,032	90.12	89.13	89.01	90.24	2.22	2.27	1,344	1,385	8.71	9.27
I_4M_1	235	241	9.2	9.3	1,033	1,011	93.21	93.95	92.71	93.95	2.27	2.34	1,343	1,405	8.76	9.39
CD (P=0.05)	NS	NS	NS	NS	NS	9.52	NS	NS	1.74**	2.88**	0.06**	0.05**	26.00**	43.00**	0.38**	NS

Details of treatments are given in Materials and Methods

Table 2. Effect of methods of irrigation and trash mulching on the nutrient uptake of sugarcane at harvest

Treat-ment	Total uptake of N (kg/ha)		Total uptake of P (kg/ha)		Total uptake of K (kg/ha)		Total uptake of Ca (kg/ha)		Total uptake of Na (kg/ha)		Total uptake of Fe (kg/ha)		Total uptake of Mn (kg/ha)		Total uptake of Zn (kg/ha)		Total uptake of Cu (kg/ha)	
	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop
I_1	146.1	170.9	52.0	56.1	96.5	109.7	77.2	79.7	53.5	54.3	22.7	24.4	2.56	3.39	0.56	0.59	1.66	1.74
I_2	141.5	153.6	49.3	53.1	91.4	100.9	74.2	75.9	53.0	51.4	22.3	23.8	2.46	3.27	0.55	0.57	1.65	1.63
I_3	102.5	115.8	35.2	39.2	62.4	71.9	55.1	56.1	38.1	37.6	14.3	13.3	1.71	2.12	0.39	0.42	1.23	1.23
I_4	109.0	121.6	37.1	40.4	65.3	77.5	58.9	59.5	41.5	42.2	15.1	14.4	1.87	2.30	0.42	0.45	1.30	1.31
CD (P=0.05)	10.33**	11.99**	2.18**	1.91**	4.48**	5.04**	2.25**	2.10**	4.07**	3.70**	1.10**	1.08**	0.09**	0.31**	0.02**	0.01**	0.07**	0.04**
M_0	115.4	131.3	39.7	43.5	71.8	82.4	60.1	60.8	39.8	40.4	13.2	14.4	1.83	2.34	0.44	0.46	1.36	1.36
M_1	134.2	149.6	47.1	50.9	86.0	97.6	72.6	74.9	53.2	52.4	24.0	23.5	2.47	3.20	0.53	0.56	1.56	1.59
CD (P=0.05)	7.30**	8.48**	1.54**	1.35**	3.17**	3.56**	1.59**	1.49**	2.28**	2.61**	0.77**	0.96**	0.06**	0.24**	0.01**	0.01**	0.05**	0.03**
I_1M_0	135.2	16.3	48.1	53.1	81.1	102.5	10.7	13.2	46.6	47.8	18.2	20.2	2.20	2.86	0.52	0.56	1.56	1.62
I_1M_1	187.0	175.4	55.9	59.1	103.9	116.8	83.8	86.1	60.5	60.9	27.2	28.6	2.92	3.92	0.60	0.63	1.75	1.85
I_2M_0	129.8	135.5	44.5	47.9	81.8	90.6	86.3	6.8	45.7	43.7	17.3	18.5	2.09	2.83	0.50	0.52	1.49	1.46
I_2M_1	153.1	171.7	54.1	55.4	101.0	111.3	82.1	85.0	60.4	59.1	27.3	28.7	2.84	3.71	0.59	0.62	1.81	1.80
I_3M_0	97.0	108.4	31.3	36.0	86.2	64.2	47.9	49.1	31.3	31.5	8.5	8.8	1.45	1.73	0.35	0.36	1.17	1.14
I_3M_1	107.9	123.2	38.6	42.4	68.6	79.5	62.4	63.2	44.9	43.8	20.1	17.8	1.98	2.52	0.44	0.47	1.30	1.32
I_4M_0	99.4	115.1	34.3	37.3	60.1	72.1	55.6	53.9	35.8	38.7	9.0	9.9	1.59	1.95	0.37	0.40	1.21	1.23
I_4M_1	110.6	128.0	39.9	43.5	710.6	83.0	62.2	65.1	47.2	45.7	21.2	19.0	2.15	2.65	0.47	0.50	1.39	1.38
CD (P=0.05)	NS	NS	NS	NS	NS	NS	3.18**	2.98**	NS	NS	1.55**	NS**	0.12**	NS	NS	NS	NS	0.06**

Details of treatments are given in text

nate furrow irrigation (I_1) appreciablly increased the values of WUE, energy-use efficiency and energy productivity and was statistically superior to all other methods of irrigation.

The adequate supply of soil moisture under all furrow (I_1) and alternate furrow irrigation (I_2) might have favoured the root proliferation and penetration, thereby covering large soil-root volume resulting in the high mobility and uptake of nutrients. This might have enhanced the number of millable canes, production of thicker and heavier canes. The above factors might have attributed for registering maximum cane yield. Under skip furrow irrigation (I_3), the moisture contribution from the irrigated furrow to the permanently unirrigated furrow was much less. Similarly, irrigating the crop once in a month (I_4) was also unable to retain adequate soil moisture due to increased interval between irrigation. This might have detracted the growth and yield attributes resulting in lower yield. Acute moisture stress would markedly decreased the thickness of cane, stalk height and number of millable cane (Singh *et al.*, 1986).

Effect of trash mulching

The trash mulching in both plant crops showed significant effect on yield attributes, cane yield nutrient uptake, WUE, energy use efficiency and energy productivity influenced (Tables 1, 2). Trash mulching @ 5 tonnes/ha (M_1) exerted positive influence on all yield attributes and increased the cane yield compared to unmulched plot (M_0). The mulched treatment showed an yield increase of 6.23% over the control. The impact of mulching was reflected on the uptake of nutrients and was highest in the mulched treatments (M_3). Trash mulching (M_1) also made perceptible increase for WUE, energy productivity and energy use efficiency and showed its superiority to unmulched treatments (M_0). Application of trash might have mediated favourable environment by reducing the soil temperature and retaining more amount of soil moisture in the root zone. This might have ultimately produced positive effects on yield parameters, nutrient uptake and attributed for increasing the values of cane yield, WUE, energy-use efficiency and energy productivity. The results are in agreement with the findings of Pandian *et al.* (1992) and Mathew *et al.* (2003).

Interaction

The interaction between methods of irrigation and trash mulching was significant for cane yield, WUE and energy productivity in both plant crops. However, the interaction effect was found only with the uptake of Ca in both plant crops, with the uptake of Fe and Mn and energy-use efficiency in first plant crop and with the uptake of Cu in second plant crop (Tables 1, 2).

Among the treatment combinations, trash mulching with all furrow irrigation (I_2M_1) and alternate furrow irrigation (I_2M_1) produced comparable cane yield and were statistically superior to all other treatment combinations. Mulching recorded 10.46% yield increase in alternate furrow irrigation, while in all furrow, skip furrow and irrigation once in a month, such a benefit of mulching was not noticed. In higher and lower levels of irrigation, the benefit of mulching was comparatively less. The present results are in accordance with the findings of Thanki *et al.* (1999) and Verraputhrian *et al.* (1999).

The interaction effect also revealed that alternate furrow irrigation with trash mulching recorded highest values for WUE, energy productivity and energy-use efficiency. In the present study, alternate furrow irrigation with trash mulching (I_2M_1) recorded higher cane yield in both years and it was comparable with that of all furrow irrigation with trash mulching (I_1M_1). This might be the reason for the treatment combination of alternate furrow irrigation with trash mulching to record higher values for WUE. The result revealed a saving of water to the tune of 41% was possible in alternate furrow irrigation with trash mulching (I_2M_1) compared to all furrow irrigation with or without trash mulching. The results are conformity with the findings of Patel *et al.* (1989) and Veeraputhiran *et al.*, (1999). The highest energy productivity and energy-use efficiency associated with alternate furrow irrigation under trash mulching (I_2M_1) might be owing to the increased cane yield, higher rate of biomass production and high water-use efficiency compared to other methods of irrigation with or without trash mulching.

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