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Review/Overview

Yield, quality and irrigation water-use efficiency in sugarcane (*Saccharum officinarum*) as influenced by pre-planting tillage and crop-establishment methods in *tarai* belt of Uttarakhand

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ABSTRACT

A field experiment was conducted at Pantnagar, Uttarakhand to evaluate the effect of pre-planting tillage practices and crop-establishment methods on summer sugarcane (*Saccharum officinarum* L.) during 2012–13. Crop grown in the absence of pre-planting tillage gave 1.4 t/ha higher cane yield. It also resulted in marginally higher commercial cane sugar (CCS) and irrigation water-use efficiency compared to conventional tillage. Trench planting resulted in the maximum cane yield (90.8 t/ha) and CCS (10.7 t/ha). Irrigation water-use efficiency was found to be the maximum (5.20 t/ha-cm) in both dual row trench and pit planting methods.

Key words **:** Crop-establishment method, Crop production, Commercial cane sugar, Sugarcane, Tillage, Yield

Sugarcane is grown in a considerable area after harvesting of wheat crop in the plains of northern India. Delayed planting up to the end of April or early May results in 30–50% cane yield reduction owing to reduced crop duration and less tillering due to early initiation of elongation stage. Further, hot summer during emergence phase leads high evapo-transpiration, making growing environment less congenial for proper crop establishment. The conventional tillage which is mostly followed for sugarcane planting accelerates the rate of moisture losses besides escalating the cost of cultivation. Further, during summer months, on one hand, the water-availability for irrigation is short and available water sources also shared by other water-demanding crops like summer rice and mentha which demand adoption of water-efficient planting methods. By avoiding the pre- planting tillage operations, crop residues could be helpful for retaining the moisture for longer period (Donk *et al.,* 2010). Crop residues also regulate the soil temperature (Beyaert *et al*., 2002), suppress the weeds, lower the cost of cultivation and also the moisture loss during land preparation can be minimized in no pre-planting tillage operations.

Thus, presence of residues on the soil could be helpful for increasing the productivity of late-planted sugarcane by mitigating the heat stress *vis-a-vis* moisture depletion. Presently, in north India, sugarcane is planted employing flat method which is easy in operation and takes less time in planting but results in lower germination (30–35%) and plant population (Singh *et al*., 2009). Some preliminary studies have indicated yield advantage with alternate planting methods like pit, trench and paired row trench planting over the flat method (Yadav and Kumar, 2005). Trench planting saves irrigation water and reduces crop lodging due to easiness in inter-culture and earthing-up operations. Dual row trench planting consistently increases cane yield over single row planting under wider rows (Sundra, 2003). Pit planting encourages the number of mother shoots suppressing the secondary and tertiary tillers, thus has the potential of almost doubling the cane yield. The results have been variable due to planting methods, particularly with respect to crop and water productivity and juice quality parameters. Furthermore, their effect may vary depending upon the type of tillage practice followed. Hence, present study was conducted.

A field experiment was conducted at the Norman E. Borlaug Crop Research Centre, GBPU A&T, Pantnagar, during the summer season of 2012–13. The site is located at 29°N, 79.5°E at an elevation of 243.8 m above the mean

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sea-level under the foothills of Shivalik range of Himalayas, representing the *tarai* region of Uttarakhand. The soil was silty clay loam, low in available N (249.3 kg/ha), high in available P (33.5 kg/ha), organic carbon (1.08%) and medium in available K (258.7 kg/ha) with neutral in reaction (pH 7.1). The bulk density of top 0–15 cm soil was 1.46 Mg/m^3. The soil moisture content at field capacity and permanent wilting point in the upper 0–30 cm surface was 22.9 and 7.4% respectively. The infiltration rate of soil was 1.3 cm/hr. The experiment with 10 treatments, comprising 2 pre-planting tillage practices (with and without pre-planting tillage) and 5 planting methods (conventional, ridge and furrow, trench, dual row trench and pit planting) was laid out in factorial randomized block design with 3 replications. Sugarcane variety 'Co Pant 90223' was planted on 26 April 2012 and harvested on 16 February 2013. For flat and trench planting; 15 cm deep furrows were opened at 60 cm distance with the help of tractor mounted furrow opener. Further, in trench planting, the soil from the first furrow was removed with the help of a small spade to increase its depth up to 20–25 cm. Then cane setts were placed and covered by the soil removed from the next furrow and so on except in pit method. Three-budded, 4 setts/m furrow length were placed in bud-to-bud fashion. In flat method, the furrows were completely covered with soil while in trench and pit plantings, initially the furrows and pit were half filled. In pit method, the distance between centres of 2 pits was 90 cm with actual pit diameter of 60 cm. Pits were prepared manually and after fertilizer application, 2 budded 10 setts were placed in a circular fashion. At the time of last intercultural operation at the end of June, the trenches and pits were completely filled with soil making the surface flat. Dual row trenches were made at a spacing of 40/80 cm. In ridge planting, crop was sown as flat and setts were covered up to more height to make the ridges. In no pre-planting tillage treatment, the preceding wheat crop was harvested manually at 25 cm above the soil surface. Furrows were opened directly with the help of tractor-mounted furrow opener in untilled field. The crop was uniformly fertilized with 150 kg N, 26.2 kg P and 33.2 kg K_2O/ha. One-third dose of nitrogen and the entire amount of phosphorus and potassium were applied basal. The remaining N was top-dressed in 2 equal splits-in the last week of May and June respectively. Pre-sowing irrigation was applied to ensure a good sett germination and smooth field preparation. After the crop establishment, 4 irrigations were applied till the commencement of monsoon. During the crop period, a total rainfall of 1,007.3 mm was received in 46 rainy days. The depth of irrigation in flat, ridge and furrow, trench, dual row trench and pit planting methods was 6, 6, 4.8, 3.4 and 4.2 cm respectively. Irrigation water-use efficiency (WUE) was worked out by dividing the cane yield (t/ha) by total irrigation depth (cm). Emergence percentage and number of shoots/ha were recorded at 45 and 150 days after planting (DAP) respectively. After clarifying the juice with lead sub-acetate, the optical rotation of juice was determined by Bosch and Lomb type polarimeter to estimate the sucrose concentration. The sugar yield was calculated by multiplying the CCS (%) with cane yield and dividing by 100.

Crop raised with no pre-planting tillage exhibited 2.7% higher emergence than that of with conventional tillage. This could be attributed to beneficial effect of wheat crop residues, by mitigating the heat stress during the high ET period, by way of conserving moisture. Among the crop-establishment methods, trench method of planting resulted in the maximum emergence (36.5%), being at par with pit method (33.9%) but was significantly superior to the remaining planting methods. Higher emergence percentage in trench could be ascribed to the adequate soil moisture on account of deep placement of setts with moderate soil cover over the cane setts. These conditions might have supported to protrude buds from the soil surface (Singh *et al.,* 2012). In the absence of pre-planting tillage, crop produced 7.5% higher shoot population than conventional tillage at 150 days after planting. The higher shoot population under no pre-planting tillage treatment is ascribed to the higher emergence percentage and better tillering. Trench planting produced the maximum number of shoots which was significantly superior to the other crop-establishment methods. Enhanced emergence and early establishment of plants under trench planting resulted in significantly higher number of shoots over the other methods. Localized application of fertilizers and water in the trenches might have favored the absorption of nutrients and water as most of the roots are concentrated with in the trenches. Dual row trench produced the lowest number of shoots. Number of millable canes also followed the similar as that of number of shoots. No pre-planting tillage produced 1.9% more millable canes than conventional tillage. Trench planting recorded the maximum millable canes which remained at par with pit and ridge and furrow method but was significantly superior to the flat and dual row trench methods**.** The minimum number of millable canes was recorded in dual row trench method. Number of millable canes depends on the shoot population, tillers mortality and conversion of shoots to millable canes. The number of millable canes was significantly higher in trench planting owing to higher shoot population as a result of more emergences of buds.

Cane length did not vary significantly due to tillage operations (Table 1). Dual row trench planting resulted in the maximum cane length which was at par with that of the trench, pit and ridge and furrow methods being significantly superior to the flat planting (Table 1). The higher cane length in dual row trench could be attributed to more shoot height. Individual cane weight did not vary significantly due to tillage operations and crop-establishment methods. Pre-planting tillage treatments did not affect the cane yield significantly. Crop grown in the absence of pre-planting tillage operation produced 1.4 t/ha higher cane yield than of the conventional tillage (Table 1). Non-significant difference in number of millable canes and individual cane weight between conventional tillage and no-pre-planting tillage method led to comparable cane yields. Trench planting produced at par cane yield with pit and ridge and furrow methods, but resulted in significantly higher cane yield over the flat and dual row trench plantings. The lowest cane yield was recorded in dual row trench method. Cane yield is a function of number of millable canes and weight of individual cane. The higher cane yield under trench planting method could be attributed to more number of millable canes and relatively more individual cane weight. Pit method recorded the second highest cane yield, next to the trench planting. Increased cane yield in pit planting over ridge and furrow, flat and dual row trench planting could be assigned to more number of millable canes and individual cane weight as a result of more contribution of the proportion of mother shoots in cane population under pit planting than secondary and tertiary tillers in flat planting. Moreover, these secondary and tertiary tillers continue to depend on primary shoots until they form their own roots, thus restricting development of the primary shoot in flat planting. The localized placement of fertilizers in pit method increases nutrient-use efficiency *vis-a- vis* enhances production of healthy canes (Gupta *et al.*, 2004; Yadav, 2004). Crop grown with no pre-planting tillage gave 4.9% higher green top yield over the conventional tillage treatment (Table 1), but the differences were not significant. The maximum green top yield produced under trench planting was significantly superior over the remaining crop establishment methods. Dual row trench recorded the lowest green top yield. Higher green top yield in trench was a result of higher shoot population and relatively good leaf area. It produced 48.8% higher shoot population than dual row trench planting (Table 1). Alike green top, trash yield also followed the similar trend.

No pre-planting tillage treatment gave 6.4% higher commercial cane sugar than the conventional tillage but it was not enough to be significant alike sucrose content. Trench method recorded the maximum commercial cane sugar (CCS), being at par with pit, ridge and furrow and flat methods but was significantly superior to the dual row trench planting. Poor performance of the dual row trench

Table 1. Effect of pre-planting tillage and crop establishment methods on yield, yield attributes, quality and irrigation water-use efficiency of sugarcane

Treatment	Emergence (%)	Number of shoots ($\times 10^3$ ₹/ha)	Millable canes ($\times 10^3$ ₹/ha)	Cane length (cm)	Individual cane weight(g)	Cane yield (t/ha)	Green topyield (t/ha)	Trash yield (t/ha)	Sucrose (%)	CCS (t/ha)	Irrigation depth (cm)	Irrigation WUE (t/ha-cm)
Tillage practice												
Conventional tillage	31.6	149.60	101.88	175	884	82.1	18.5	7.0	16.5	9.4	19.5	4.21
No pre-planting tillage	34.3	160.84	103.80	184	890	83.5	19.4	7.2	16.9	10.0	19.5	4.28
SEm±	0.6	4.62	1.24	4.0	114	1.8	0.4	0.2	0.2	0.3	-	-
CD (P=0.05)	1.9	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-
Crop establishment method												
Flat	30.3	141.19	102.66	162.7	875	80.9	16.3	6.6	16.8	9.5	24.0	3.37
Ridge and furrow	32.8	142.19	103.26	179.6	889	84.4	17.8	7.4	16.5	9.7	24.0	3.52
Trench	36.5	196.35	108.45	181.0	904	90.8	23.9	8.8	16.9	10.7	19.2	4.73
Dual row trench	31.6	131.98	92.18	197.6	878	70.7	15.1	5.2	16.6	8.3	13.6	5.20
Pit	33.9	164.39	107.64	179.8	891	87.4	21.6	7.4	16.9	10.4	16.8	5.20
SEm±	1.0	7.30	1.96	7.0	180	2.8	0.6	0.2	0.3	0.5	-	-
CD (P=0.05)	2.9	21.69	5.83	20.9	NS	8.3	1.7	0.7	NS	1.4	-	-

CCS, Commercial cane sugar; WUE, Water-use efficiency planting could be attributed to limited water supply, i.e. only in the furrow and 1 furrow was supposed to cater the water need of 2 rows which lead to poor initial growth, especially the tillering. This consequently resulted in lower yields and juice quality. No pre-planting tillage treatment had almost similar irrigation water-use efficiency with that of conventional. Among the crop-establishment methods, the maximum total of irrigation water depth was used in flat and ridge and furrow methods. It was only 19.2 cm in trench, 13.6 in dual row trench and 16.8 cm in pit method of planting. It indicates that trench, dual row trench and pit methods required 4.8, 10.4 and 7.2 cm, respectively, less irrigation water as compared to both the flat and the ridge and furrow plantings. Pit and dual row trench planting recorded the maximum irrigation water-use efficiency. This may be ascribed to relatively more cane yield produced by utilizing less water. Pit and dual row trench required 2.4 and 5.6 cm less irrigation water than trench planting. The lowest irrigation WUE was obtained in flat planting owing to less cane yield by receiving more amount of water.

As summer planted sugarcane in no-tillage condition exhibited better emergence, shoot population, juice quality, yield and irrigation water-use efficiency, it can be planted without land preparation with standing wheat stubbles. Trench planting had an edge over other methods in terms of quality, yield and irrigation WUE, hence, can be advocated.

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