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Response of Summer Planted Sugarcane (*Saccharum officinarum* L.) to Tillage Practices and Planting Methods

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A field experiment was conducted to study the effect of tillage practices and planting methods on the performance of summer planted sugarcane at GBPUA&T, Pantnagar. Ten treatments comprising two tillage practices (conventional and no pre-planting tillage) and five planting methods (flat, ridge & furrow, trench, dual row trench and pit planting) were laid out in factorial randomized block design with three replications. No pre-planting tillage significantly increased the emergence percentage over conventional tillage besides attaining the more plant height, leaf area index and number of green leaves. Among different planting methods, maximum emergence (36.48 %) was noticed in trench method. In terms of growth, viz; plant height, number of green leaves and LAI, dual row trench method showed superiority over the remaining methods of the planting . Trench planting gave the maximum number of shoots which in turn also reflected in the maximum number of millable canes (108448 ha^{-1}). In spite of non significant differences, no pre-planting tillage produced 1.4 t ha^{-1} higher cane yield than conventional tillage. No pre planting tillage gave Rs. 10586 ha^{-1} and Rs. 13311 ha^{-1}, higher gross and net return, respectively than conventional tillage and also had 12.1 per cent higher benefit cost ratio than conventional tillage. Trench method produced the maximum cane yield (90.8 t ha^{-1}) which was significantly higher than flat and dual row trench planting. It also gave the maximum gross (Rs. 272989 ha^{-1}), net return (Rs. 189278 ha^{-1}) and B:C ratio (2.26).

Key words: Net return, Planting method, Sugarcane, Tillage, Yield

At present, cane productivity is low (70.3 t ha^{-1}) against the national target (100 t ha^{-1}) and the late planting of sugarcane is one of the major constraints for its low productivity. In rice-wheat- sugarcane-ratoon- wheat crop rotation, which covers more than half of the cultivated area in sub-tropical north-west India, late planting of sugarcane, after harvesting of wheat, is quite common. Delayed sowing and high temperature at planting affects the plant population and reduces crop duration. An early initiation of elongation phase of sugarcane in response to increased atmospheric humidity associated with the onset of monsoon leaves less time for sugarcane to produce tillers**,** which results in lower number of millable canes and productivity (Yadav and Kumar, 2005). Yadav and Singh (1997) observed 30 to 50 per cent lower cane yield with delayed planting upto the end of April or early May. Further, hot summer leads to high evapo- transpiration, making growing environment less favourable for proper crop establishment.

Tillage management is a vital practice for creating favourable soil conditions for crop germination, growth and development. In North India, sugarcane is mostly grown under conventional tillage system. However, in conventional tillage, severe disturbance of the top soil leads to accelerated moisture loss hampering the germination particularly that of summer cane which coincides with high evaporation. In conventional tillage, the crop residues of previous crop (mostly wheat) are also not utilized thus does not add to soil health resulting in loss of valuable source of organic matter and soil health impoverisation. Moreover, frequent tillage operations for preparation of land besides delayed sowing also escalate the cost of cultivation as well as loss of organic carbon through oxidation. No disturbance to the land till planting may help in better availability of moisture and safeguard the oxidation of organic carbon which can greatly support the germination process. Presence of residues in no- tillage system can be beneficial in conserving moisture, suppressing weeds, adding organic matter and reducing soil losses besides lowering the cost of cultivation. Residue cover is a major factor in regulating soil temperature and availability of soil moisture (Beyaert *et al*. 2002). Thus, presence of residues on the soil could be helpful for increasing the late planted sugarcane productivity by mitigating the heat stress as well as by maintaining better soil health. Adoption of a suitable planting method is of utmost significance as due to variation in planting technique, the microclimate in immediate vicinity of

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crop plants gets altered, thereby affecting cane growth and development. Presently, in North India, flat planting is the common method, which is though less time consuming but results in lower germination (30-35%) and plant population (Singh *et al*. 2009). Studies have shown a yield advantage with alternate planting methods like pit and trench over flat planting (Yadav *et al.* 1990; and Yadav and Kumar, 2005). Trench planting saves irrigation water and reduces crop lodging due to easiness in inter-culture and earthing-up operations (Malik *et al*. 1996). Dual row trench planting consistently increases cane yield over single row planting under wider rows (Sundra, 2003). Pit planting, developed by Singh *et al.* (1984) 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 productivity and economics. Further, their effect may vary depending upon the type of tillage practice followed. For summer sugarcane crop, which suffers severely due to harsh climate during its establishment phase and the shortening of vegetative phase, these practices may be useful in augmenting its productivity. Therefore, present study was undertaken to study the influence of pre-planting tillage and planting methods on sugarcane growth, productivity and profitability.

Materials and Methods

Field experiment was carried out at the Norman. E. Borlaug Crop Research Centre, GBPUA&T, Pantnagar during the summer season of 2012-13. The site is located at 29°N latitude, 79.5°E longitude at an elevation of 243.8 meters above the mean sea level under the foot hills of *Shivalik* range of Himalayas, representing the *tarai* region of Uttarakhand. The soil was silty clay loam in texture, low in available nitrogen (249.3 kg ha^{-1}), high in available phosphorus (33.5kg ha^{-1}), organic carbon (1.08%) and medium in available potassium (258.7kg ha^{-1}) with neutral in reaction (P_H 7.1). The bulk density of top 0-15cm 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 with infiltration rate of 1.3cm hr^{-1}. The experimental layout accommodated 10 treatments comprising 2 pre- planting tillage practices (with and without pre-planting tillage) and 5 planting methods (conventional, ridge & furrow, trench, dual row trench and pit planting) was laid out in Factorial Randomized Block Design with three replications. Sugarcane variety Co Pant 90223 was used for the study. Crop was planted on April 26, and harvested on Feb 16, 2013. In conventional tillage treatment, after land preparation, for flat and trench planting; 15 cm deep furrows were opened at 60 cm distance with the help of tractor mounted furrow opener. In trench planting, soil from the first furrow was removed with the help of a small spade to increase its depth about 20- 25 cm. Then cane setts were placed and these were covered by the soil removed from the next furrow, and so on. In flat and trench methods, three budded, 4 setts per meter furrow length were placed in bud to bud fashion. In flat method, the furrows were completely filled with soil while in trench and pit plantings, initially the furrows and pit were half filled. In pit method, the distance between centers of one to another pit was kept 90 cm having actual pit diameter of 60 cm. Pits were prepared manually and after fertilizer application, 2 budded 10 setts were placed in a circular fashion. Pits were connected to each other to facilitate irrigation. At the time of last intercultural operation in end of June, the trenches and pits were completely filled with soil making the surface flat. Dual row trench were made at a spacing of 40/80 cm. In ridge and furrow method, crop was sown as like flat but at 60 DAP, earthing was done to make the ridges. For no pre-planting tillage treatment, the preceding wheat crop was harvested manually at 15 cm above the soil surface. Furrows were opened directly with the help of tractor mounted furrow opener in untilled field and sugarcane sets were planted as in case of conventional tillage treatments. The crop was uniformly fertilized with 150 kg N, 60 kg P_2O_5 and 40 kg K_2O per hectare. One third dose of nitrogen and the entire amount of phosphorus and potassium were applied as basal at the time of planting. The remaining N was top dressed in two equal splits in the last week of May and June, respectively. Pre-sowing irrigation was applied to ensure a good sett germination and for smooth field preparation. After the crop establishment, 04 irrigations were given till the commencement of monsoon. During the crop period, a total rainfall of 1007.3 mm was received in 46 rainy days. The irrigation depth of 6 cm was maintained through Parshall flume. Emergence percentage was noted at 45 DAP; while, growth parameters were recorded at 150 DAP. Leaf area index was measured by using the Ceptometer. The economics was worked out as per prevailing market prices of input and output.

Results and Discussion

Growth parameters

Crop raised with no pre-planting tillage exhibited significantly higher emergence percentage than conventional with the difference of 2.7 per cent. The higher per cent emergence under no pre -planting tillage condition could be due to beneficial effect of wheat crop residues on mitigating the heat stress during the high ET period, by way of conserving moisture. Further, in no-tillage, the soil moisture loss from the seed zone layer was likely to be less, as the soil was not disturbed, which probably helped in retaining higher moisture at the time of planting. Among the crop establishment methods, trench planting gave significantly higher emergence (23.48 %) over the remaining methods except the pit planting. Higher emergence percentage under trench method could

be ascribed to the adequate soil moisture on account of deep placement of setts and thin soil cover over the cane setts. These conditions required less energy to protrude buds from the soil surface. The least emergence was noticed in flat planting though the differences among the flat, ridge and furrow and dual row trench methods were found to be non-significant. The lowest emergence in flat planting could be assigned to a thick 10-15 cm soil covering over setts which imparted more resistance to emerging shoots. Some of them failed to reach the surface and resulted in reduction of emergence percentage under flat planting. Singh *et al.* (2009) have also reported similar results.

No pre-planting tillage produced significantly

Table 1. Growth parameters of sugarcane as influenced by pre- planting tillage and planting methods

Treatment	Emergence (%) at 45 DAP	150 DAP		
		Shoot height (cm)	Number of shoots ha^{-1}	Leaf Area Index
Tillage Practice				
Conventional tillage	31.65	252.5	149603	1.99
No pre-planting tillage	34.33	284.1	160837	2.59
SEm±	0.62	7.4	4619	0.06
CD (P=0.05)	1.86	22.0	NS	0.18
Planting method				
Flat	30.26	265.1	141190	2.14
Ridge and furrow	32.76	275.4	142185	2.37
Trench	36.48	279.7	196349	2.30
Dual row trench	31.58	284.7	131981	2.62
Pit	33.86	236.4	164396	2.01
SEm±	0.99	11.7	7303	0.10
CD (P=0.05)	2.94	34.8	21696	0.29

taller plants than the conventional tillage with the difference of 13.1 per cent. Better soil moisture regime created by wheat residues in no pre-planting tillage, favoured more cell elongation and cell division which in turn resulted in more shoot height. Donk *et al.* (2010) also observed 6 cm higher moisture in residue covered soil. Among the different planting methods, dual row trench method recorded the maximum shoot height comparable with that of the trench, ridge & furrow and flat methods being significantly superior over the pit planting. Higher shoot height under dual row trench planting could be due to the fact that narrow row spacing between two rows resulted in more competition among the plants for sunlight which, in turn caused more shoot height. Further, it may be supported by paired row planting configuration in dual row trench planting. Chattha *et al*. (2007) also noted significant increase in shoot height under paired planting geometry over flat planting. In the absence of pre-planting tillage operation, crop produced higher number of shoots than that under conventional planting. The percent increase in number of shoots with no pre-planting over conventional was to the tune of 7.5 %. Higher shoot population under no pre-planting tillage treatment was due to higher emergence percentage and better tillering. Planting methods also produced significantly different number of shoots. Trench planting produced maximum number of shoots significantly superior to the remaining planting methods. An enhanced emergence and early establishment of plants under trench planting resulted in significantly higher number of shoots as compared to the other planting methods. Further, localized application of fertilizers and water in the trenches favoured the efficient absorption of nutrients and water as most roots were concentrated within the trenches might be the cause for higher shoot population under trench planting. The results are in line with the findings of Singh *et al*. (2013).

Number of green leaves per shoot continued to increase upto 150 DAP. Crop raised in no pre-planting tillage treatment produced significantly higher number of green leaves per shoot than that of conventional tillage. At 150 DAP, no pre-planting tillage produced 2.4 per cent more leaves per shoot over the conventional tillage treatment. Favourable effect of no pre- planting tillage on plant height could be ascribed to better moisture regimes created by residues which influenced most of the physiological process in plants subsequently resulted in higher number of green leaves. Rodrigues *et al.* (2009) also observed similar findings. Among the planting methods, dual row trench method produced the maximum number of green leaves at all the stages of growth. At 150 DAP, it was at par with ridge and furrow, flat and trench methods but produced significantly higher number of green leaves (12.7) than that of the pit planting. Production of more leaves per shoot in dual row trench (40/80 cm) could be attributed to the border effect. Better light interception and proper aeration facilitated by wider spacing available between two paired rows could help in increasing the ability of shoot to produce more green leaves. The results are in accordance with the findings of Bhullar *et al*. (2008).

Leaf area index, which represents the measure

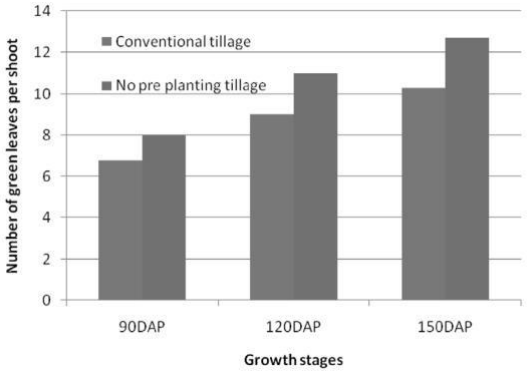

Fig. 1.a. Effect of tillage practices on number of green leaves

of photosynthetic capacity of the crop, varied significantly due to different treatments. Crop planted with no pre-planting tillage had significantly higher leaf area index over the conventional tillage. Zero tilled crop attained 30.2 per cent higher leaf area

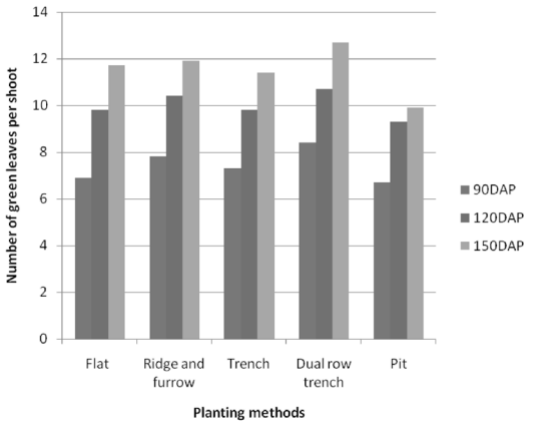

Fig.1.b. Effect of planting methods on number of green leaves

index than the conventional tillage (1.99). Crop establishment methods also caused significant differences in LAI of sugarcane. Dual row trench method recorded the maximum leaf area index, comparable with the ridge and furrow method but significantly superior over remaining methods of planting. The lowest LAI was noticed in pit planting. Leaf area index, the ratio of leaf area to ground area, was higher in dual row trench method due to production of more number of green leaves per shoot and better leaf growth. Dual row trench method produced 13.6, 21.2 and 24.2 per cent more green leaves as compared to the trench, flat and pit planting, respectively. Tillage operations failed to bring significant differences in cane dry matter though it was marginally higher in no-preparatory tillage condition than conventional tillage (Fig 2 a). Planting methods also did not improve the cane dry

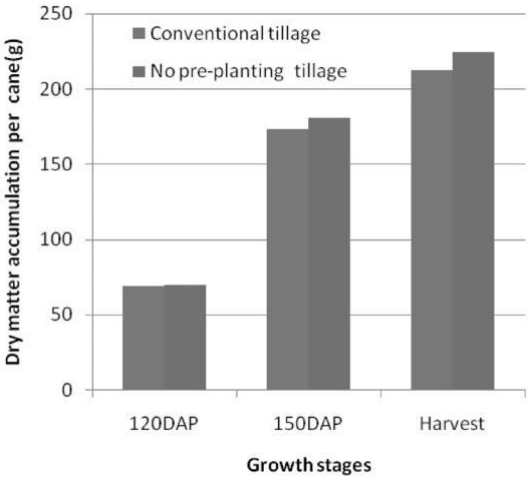

Fig. 2. a. Effect of tillage practices on dry matter accumulation in cane

matter significantly, though, it ranged from 234.4 to 204.1 g, respectively in pit and dual row trench methods.

Yield attributes and yield

In spite of a non significant difference, no pre-planting tillage produced 1.9 per cent more number

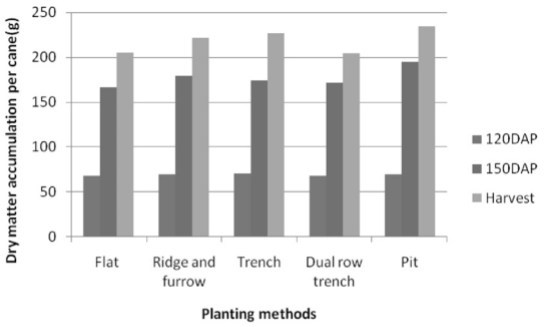

Fig. 2.b. Effect of planting methods on dry matter accumulation in cane

of millable canes than conventional tillage (Table 2). Trench planting recorded the maximum number of millable canes which remained at par with pit and ridge & furrow method but was significantly superior over the flat and dual row trench methods (Table 2). Minimum number of millable canes (92181 ha^{-1}) was noticed in dual row trench method. Number of millable canes, which is one of the deciding factors for the cane yield, depends upon the shoot population, tillers mortality and conversion of shoots to millable canes. The number of millable canes was significantly higher under trench planting due to higher shoot population as a result of more emergence of buds. Tillage practices remained at par with respect to individual cane weight. Non significant differences were observed among planting methods, however trench planting produced the heaviest cane (904 g) followed by pit planting (891 g). The lowest individual cane weight was observed in flat planting (875 g).

No pre-planting tillage operations were statistically at par with the conventional tillage with respect to cane yield. However, crop grown in absence of pre-planting tillage operation produced 1.4 t higher cane yield than the conventional tillage (Table 2). Non significant difference in yield attributes *viz*; cane girth, cane weight, *etc* . between conventional and no pre-planting tillage method led to parallel cane yields in these treatments. Among the crop establishment methods, trench planting remained at par with pit and ridge and furrow methods, but gave significantly higher cane yield over the flat and dual row trench plantings (Table 2). The lowest cane yield (70.7 t ha^{-1}) was noticed in dual row trench method. Ridge and furrow, flat planting methods also showed significantly higher cane yield than that of the dual row trench method, but both the former treatments did not differ significantly with the pit planting. 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 planting recorded yield next to trench. 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

Table 2. Yield attributes, yield and economics of sugarcane as influenced by tillage practices and planting methods

Treatment	Individual cane weight (g)	Number of millable canes ha^{-1}	Cost of cultivation (Rs. ha^{-1})	Cane yield (t ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Tillage Practice							
Conventional tillage	101875	884	82.1	88838	238431	149593	1.73
No pre-planting tillage	103801	890	83.5	86112	249017	162904	1.94
SEm±	1241	111	1.8	-	3472	3472	0.04
CD (P=0.05)	NS	NS	NS	-	10314	10314	0.12
Planting method							
Flat	102660	875	80.9	79653	234156	154503	1.94
Ridge and furrow	103260	883	84.4	81670	245628	163958	2.00
Trench	108448	904	90.8	83711	272989	189278	2.26
Dual row trench	92181	878	70.7	74611	203226	128617	1.73
Pit	107640	891	87.4	117731	262620	144889	1.23
SEm±	1963	180	2.8	-	5489	5489	0.07
CD (P=0.05)	5831	NS	8.3	-	16308	16308	0.20

individual cane weight. Singh (2002) also noticed direct contribution of yield attributing characters to yield of sugarcane crop in order of number of millable canes (40%) followed by the individual cane weight (30%), cane length (27%) and thickness (3%). In pit planting, the proportion of mother shoots in cane population was more as compared to the secondary and tertiary tillers, which were more prevalent in flat planting (Yadav *et al.*, 1990). The localized placement of fertilizers in pit method resulted in increased nutrient use efficiency, which also helped to produce healthy canes (Yadav, 2004 and Gupta *et al*., 2004).

Economics

Net return varied significantly, both due to the tillage practices and the crop establishment methods (Table 2). In the absence of the pre-planting tillage, crop gave Rs. 13311 ha^{-1} more net return as compared to conventional tillage owing to variation in the cost of cultivation and cane yield. Among the crop establishment methods, trench planting gave the maximum net return (Rs.189278 ha^{-1}) being significantly higher than that of the remaining planting methods because of higher economic yields. Ridge and furrow planting (Rs.163958 ha^{-1}) followed to the trench planting also fetched Rs.9455 ha^{-1} more net return over the flat planting but the difference was not enough to be significant.

Further, it furnished Rs.19069 and Rs. 35341 ha^{-1} more net returns as compared to the pit and dual row trench plantings, respectively. Pit planting, in spite of higher cane yield was inferior to ridge and furrow planting for net returns. This indicates that the relative increase in cost of cultivation in pit planting was more than that in the net return obtained due to higher cane yield. Dual row trench planting gave the minimum net returns (Rs.128617 ha^{-1}), which was significantly lower than remaining planting methods. Lower cane yield in this treatment was responsible for lower net return. Benefit cost ratio showed significant variations due to both tillage practices and planting methods. Crop planted with no pre -planting tillage gave 12.1 per cent higher benefit cost ratio as compared to the conventional tillage as it had Rs.2726 ha^{-1} less cost of cultivation (Table 2), but produced 1.4 t ha^{-1} more cane yield over the conventional tillage. Crop establishment methods also brought significant variations in benefit: cost ratio. Trench method recorded the maximum B: C ratio (2.26) due to higher net return followed by ridge and furrow method. The lowest benefit cost ratio (1.23) was obtained under pit planting. Since, in pit planting ,the additional cost incurred on planting and seed was quite high, yield enhancement due to use of these inputs could not compensate it, which resulted in lower benefit: cost ratio.

Conclusion

Based on the results obtained in the present study, it may be concluded that no pre-planting tillage can be a viable option over conventional tillage for summer cane, while on the other hand; trench planting can replace the conventional planting for higher productivity and profitability.

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