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# Enhancing sugarcane (*Saccharum* hybrid complex) productivity through modified trench method of planting in sub-tropical India

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## ABSTRACT

A field experiment was conducted during autumn seasons of 2007–09 and 2008–10 to study the effect of modified trench method of sugarcane planting at 120 cm apart placing setts across the furrow and covering them with 2.5 cm of soil layer, followed by light irrigation ($T_5$) over other planting methods, viz. conventional furrow planting at 90 cm apart ($T_1$), deep furrow (20 cm) planting at 90 cm apart covering setts with 2.5 cm of soil layer ($T_2$), paired row furrow planting at 120 : 60:120 cm ($T_3$), paired row deep furrow (20 cm) planting at 120: 60:120 cm covering setts with 2.5 cm of soil layer ($T_4$) on the growth, yield and quality of sugarcane (*Saccharum* hybrid complex) under sub-tropical climatic conditions. Experimental results revealed that $T_5$ planting method produced significantly higher cane yields of 118.7 and 121.7 tonnes/ha compared with other planting methods during both the years of experimentation. The cane yield thus obtained under $T_5$ was 18.72, 23.87, 21.22 and 27.01% higher than that of $T_4$, $T_3$, $T_2$ and $T_1$ treatments, respectively. Increase in sugar yield exhibited almost similar trend as the yield of cane under different treatments, and accordingly the $T_5$ treatment produced significantly higher sugar yield (14.18 tonnes/ha) than that obtained under rest of the treatments ranging from 10.85 to 11.70 tonnes/ha in the study. Economics of different treatments clearly indicated that by virtue of higher cane yield, the $T_5$ treatment exhibited a net returns and B:C ratio of ₹ 154 436/ha and 2.23 which were higher to the tune of 18.63 and 10.86, 20.17 and 3.59, 21.20 and 13.00 and 22.73 and 5.83% under $T_4$, $T_3$, $T_2$ and $T_1$ treatments, respectively. Conclusively, since the modified trench method of planting ($T_5$) offers benefit in terms of producing higher yields of cane and sugar over other conventional methods of planting and that would be worth adopting by farmers for increased sugarcane productivity in sub-tropical India.

**Key words:** Cane and sugar yield, Economic returns, Planting methods, Sugarcane

Sugarcane (*Saccharum* hybrid complex) is an important agro-industrial crop grown primarily for sugar production in India, and plays a pivotal role in agricultural and industrial economy of the country (Singh *et al*., 2011). Here, the crop is cultivated to an extent of 4.96 million ha, producing nearly 337 million tonnes with the productivity of 67.9 tonnes/ha (Thakur *et al*. 2007). In India, the crop is cultivated broadly under two distinct agro-climatic conditions commonly referred to as tropical and sub-tropical belts. The Area, production and productivity of sugarcane in the tropical and sub-tropical belts are 2.18 and 2.78 million ha, 178 and 159 million tonnes and 81.65 and 57.19 tonnes/ha, respectively. The productivity of sugarcane in tropical belt is 29.96% higher than that of sub-tropical belt, and this is primarily due to the ideal climatic conditions over a longer period for its growth. In spite of this, the cultivation of sugarcane in sub-tropical belt is practised in large area of India on account of the higher economic returns/unit area and time as compared to other field crops. The low productivity of sugarcane in sub-tropical belt is the major bottleneck in enhancing the overall production of cane and sugar in the country. In order to meet the per capita requirement of 35 kg sweeteners/year by 2020, India would need to produce 415 million tonnes of sugarcane having a sugar recovery and cane productivity of 11% and 100 tonnes/ha, respectively (Bachchhav 2005). This goal of high sugarcane production level coupled with higher sugar recovery without impairing soil environment and its sustainability may be achieved either through increase in area or efficient crop management practices under existing cropping system. The scope for expansion of area under sugarcane is limited due to industrialization and urbanization of cultivable lands, the production has to be enhanced only

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through effective crop management techniques. It has been seen that there is an ample opportunity to increase the productivity of sugarcane by filling the gap between potential yield as obtained in zonal varietal trials (173 t/ha) and existing state average yield (60 tonnes/ha) in Uttar Pradesh (Anonymous 1997). An increased plant population density in the form of number of millable canes and individual cane weight/unit area and time are the most important factors deciding higher sugarcane yield, and that is basically addressed by the suitable planting method. Certain modifications over earlier developed trench method (TP) may lead to modified trench method of planting (MTP) for ensuring enhanced sugarcane productivity and profitability besides improving sugar recovery. This study was, therefore, aimed to initiate it and compare this method of planting with other prevalent planting methods for its operational feasibility and production potentiality in terms of cane yield and sugar.

## MATERIALS AND METHODS

A field experiment was conducted at the research farm of UP Council of Sugarcane Research, Shahjahanpur, (27.58$^0$N latitude, 79.54$^O$E longitude and 154.53 m above mean sea level) for two consecutive years during autumn seasons of 2007–09 and 2008–10. The climate of the region is characterized by hot and dry summers and cold winters. The average weather condition during crop season 2007–09 and 2008–10 showed average annual rainfall of 1357.9 mm and nearly 85% of the total rainfall was received through north-west monsoon (second fortnight of June to September) in 48 rainy days. Soil of the experimental field was sandy loam (65% sand, 25% silt, 10% clay) in texture, neutral in *p*H (7.16–7.32), and was having the contents of available organic carbon –0.412%, nitrogen –252 kg/ha, phosphorus – 18.16 kg/ha and potassium –198.6 kg/ha with EC –0.23 dsm. The experiment consisting of five planting method treatments, viz. conventional furrow planting at 90 cm apart ($T_1$), deep furrow (20 cm) planting at 90 cm apart covering setts with 2.5 cm of soil layer ($T_2$), paired row furrow planting at 120: 60:120 cm ($T_3$), paired row deep furrow (20 cm) planting at 120: 60:120 cm covering setts with 2.5 cm of soil layer ($T_4$) and modified trench method of sugarcane planting at 120 cm apart placing setts across the furrow and covering them with 2.5 cm of soil layer, followed by light irrigation ($T_5$) was laid out in randomized block design with five replications. Sugarcane mid late maturing variety CoS 8432 was planted in first week of October and harvested in January during both the years. Two bud sugarcane setts treated with carbendazim (@ 112 g in 112 litres of water/ha were planted @ 12 buds/running meter in all the treatments except modified trench method ($T_5$). In modified trench method, trenches were opened with the help of a tractor-drawn ridger at 120 cm row-to-row spacing with 25 cm depth. The furrow bottom of trenches was dug and widened and the soil was removed to the ridges to make base 30 cm wide. The trenches were thus given a “U” shape and soil at the bottom of the trenches was stirred up for smooth placement of cane setts. Pre-treated two-bud cane setts were placed across the trenches at the distance of 10 cm as horizontal planting just like ladder. Cane setts in this method were covered with 2.5 cm thick layer of soil, followed by light irrigation in trenches. Sugarcane crop was fertilized with 180 kg N, 80 kg $P_2O_5$, 40 kg $K_2O$ and 25 kg zinc sulphate/ha. One-third of nitrogen and full doses of phosphorus, potash and zinc sulphate were applied at the time of planting. Remaining quantity of nitrogen was side dressed in four equal splits in trenches and two equal splits in other methods at proper moisture level before June. Frequent light irrigations were given in trenches till the germination process is over by 45 days after planting. After germination when plants started growing, trenches were filled up gradually with the dug soil. The filling was completed by the end of May. All the recommended package of practices were followed for raising the experimental crop in each treatment.

Observations on germination and shoots were recorded at 45 and 180 days after planting, respectively. At the time of harvesting observations on cane length, girth, weight and number of millable canes were recorded. Juice purity and commercial cane sugar (CCS) were calculated by the following formulae.

$$\text{Juice purity (\%)} = \frac{\text{Sucrose per cent in juice}}{\text{Corrected brix}} \times 100$$

$$\text{CCS (\%)} = [S- (B - S) \times 0.4] \times 0.73$$

Where, S is the sucrose percent in juice, and B is the corrected brix. Brix refers to the percentage of total solids dissolved in sugarcane juice. It was measured directly from an instrument called “Brix Refractometer” to determine the degree of ripeness of sugarcane plant. Sucrose percent in juice was determined as per the method described by Spencer and Meade (1955). Sugar yield (tonnes/ha) was calculated by multiplying CCS (%) with cane yield. Economics of the different treatments was calculated on the basis of prevailing market prices during both the years of experimentation. The data of each crop season were statistically analyzed separately. As the error variance was homogeneous, pooled analysis was done according to Cochran and Cox (1957). Since the variations among two seasons were not significant, the mean data have been presented in the paper for discussion. However, the data on yield of cane and sugar were presented year wise in the Table 2 for better interpretation of experimental results. Various treatments were compared under randomized block design. The critical difference (CD) was computed to determine statistically significant treatment differences.

$$CD = (\sqrt{2}\ VEr{-1})t_{5\%}$$

where, VE is the error variance, r is the number of replications, $t_{5\%}$ is the table value of t at 5% level of significance at error degree of freedom.

## RESULTS AND DISCUSSION

*Growth and yield of sugarcane*

Sugarcane (*Saccharum* hybrid complex) is propagated from vegetative stalk cuttings known variously as stalk setts, cane setts or seed pieces containing one, two, three or more buds. Germination of cane bud constitutes a key factor and make basis to establish a good initial crop stand and thus to ensure adequate plant population for higher cane yield at the time of harvesting. Experimental data presented in Table 1 revealed that germination of cane buds differed significantly among different treatments of planting methods. The highest germination (76.76%) was thus recorded in $T_5$ followed by 55.21, 54.02, 46.22 and 45.37% under $T_4$, $T_2$, $T_3$ and $T_1$ treatments, respectively. Moreover, deep planting either at 90 ($T_2$) or 120:60:120 cm ($T_4$) gave significantly higher germination over the same row spacing under flat planting methods ($T_1$ and $T_3$). Under flat planting in sub-tropical India, in general, the setts in furrows are covered with 10–15 cm thick soil cover which makes resistance to emerging shoots in coming up to the soil surface. The greater the soils cover over the setts, the greater the penetrating resistance of soil particles will be there to the young shoots. With the increase in the thickness of soil cover on setts, the number of shoots failed to reach the soil surface and reduced the germination percentage accordingly in flat planting methods both at 90 or 120:60:120 cm spacing. This observation is in conformity to that of Singh *et al*. (2008a). Significantly higher germination in modified trench ($T_5$) and deep planting ($T_2$ and $T_4$) methods was due to adequate soil moisture on account of deep placement of setts in the lower soil zone which is generally moist, and light soil cover over cane setts. These conditions accelerated the process for quick germination of cane buds and thus gave a good initial crop stand. The key advantage of sugarcane planting particularly in $T_5$ is associated with better root growth without any hindrance resulting in a good start of the crop. Physiologically, roots grow by a process of cell division in the apical meristem just behind the tip and cell expansion in a zone just behind the apex. Water influx into cells generates turgor pressure, which provides the driving force in order to displace soil particles, overcome friction and elongate through the soil. Therefore, water plays paramount role in the process of germination and root development. And that is why the sugarcane planted in $T_5$ treatment got adequate soil moisture which paved the way for higher germination percent of cane buds and early establishment of the crop. The $T_5$ treatment not only improved the germination per cent of cane buds, but also produced significantly higher number of shoots over $T_1$, $T_2$, $T_3$ and $T_4$ treatments. Further, an enhanced germination and early establishment of cane plants resulted in significantly higher number of shoots in comparison to other planting systems (Table 1).

Although the data on number of shoots at maximum tillering stage indicated significantly higher number of shoots in deep planting at 120:60:120 cm than that of conventional planting at 90 cm, but failed to convert into higher number of millable canes probably due to higher shoot mortality. Besides number of millable canes, cane length and single cane weight were also significantly highest in modified trench method of planting. Experimental results further revealed that $T_5$ planting method produced significantly higher cane yields of 118.7 and 121.7 tonnes/ha compared with other planting methods during both the years of

Table 1 Effect of planting methods on growth and yield attributes of sugarcane (pooled data of two years)

| Treatment | Germination (%) | No. of shoots ('000/ha) | No. of millable canes ('000/ha) | Cane length (m) | Cane girth (cm) | Individual cane weight (g) |
|---|---|---|---|---|---|---|
| $T_1$: Conventional furrow planting at 90 cm apart | 45.37 | 170.4 | 109.9 | 2.31 | 2.6 | 872 |
| $T_2$: Deep furrow (20 cm) planting at 90 cm apart covering setts with 2.5 cm of soil layer | 54.02 | 175.5 | 118.9 | 2.41 | 2.7 | 893 |
| $T_3$: Paired row furrow planting at 120 : 60:120 cm | 46.22 | 173.9 | 113.3 | 2.36 | 2.6 | 887 |
| $T_4$: Paired row deep furrow (20 cm) planting at 120: 60:120 cm covering setts with 2.5 cm of soil layer. | 55.21 | 180.6 | 126.9 | 2.46 | 2.7 | 900 |
| $T_5$: Modified trench planting at 120 cm apart placing setts across the furrow and covering them with 2.5 cm of soil layer | 76.76 | 173.3 | 137.9 | 2.86 | 2.8 | 951 |
| S Em ± | 1.01 | 2.26 | 1.76 | 0.12 | 0.06 | 13.6 |
| C D ($P$ = 0.05) | 3.08 | 6.97 | 5.43 | 0.37 | NS | 42.4 |

experimentation. The cane yield thus obtained under $T_5$ was 18.72, 23.87, 21.22 and 27.01% higher than that of $T_4$, $T_3$, $T_2$ and $T_1$ treatments, respectively (Table 2). Increase in cane yield in modified trench method of planting over other methods was entirely due to higher number of millable canes obtained on account of higher germination and low tiller mortality besides higher weight, length and girth of individual cane compared to all other methods of planting. Singh *et al*. (2008b) reported that productivity of sugarcane crop largely depends upon the quantity and quality of millable canes. Studies have recorded direct contribution of 40% of number of millable canes to the agronomic yield of sugarcane crop, followed by the length (27%), thickness (3%) and weight (30%) of cane stalk. Modified trench method of planting resulted in high proportion of mother shoots and primary tillers in the final population of millable canes, while in conventional flat method, secondary and tertiary tillers contributed most to the final population. Since secondary and tertiary tillers are shorter, thinner and lighter than the mother shoot and primary tillers (Panje 1971), their higher proportion in the final cane population resulted in lower yields. Moreover, emergence of tillers are dependent on source shoot or tiller until they have found their own roots so that development of mother shoots or primary tillers is also restricted. Significantly higher number of millable canes and lesser tiller mortality in trenches might be due to localized application of fertilizer and water in the trenches which favoured efficient absorption of nutrients and water as most roots were concentrated within the trenches.

*Juice quality and sugar yield*

The final product of cane is sugar, which is governed by juice quality. The data (Table 3) on juice quality, viz brix and CCS (%) clearly indicated that it was significantly affected by the method of planting. Modified trench method of sugarcane planting recorded significantly higher brix (19.51) and CCS% (11.86) than other planting methods. The sugar yield, which is a function of quality and cane production was significantly highest under modified trench method of planting and it was 14.34 and 14.16 tonnes/ha in both the years (Table 2). This method improved sugar yield to the tune of 30.04 and 26.90% over conventional plantings at 90 and 120:60:120 cm, respectively. The juice extracted from sugarcane cultivated under modified trench method of planting contained higher brix and CCS% because of suppression of late tillers and more number of mother shoots and primary tillers. Higher sugar yield in conventional trench and pit method over flat planting was also reported by Singh *et al*. (2008a).

Table 2 Effect of planting methods on cane and sugar yield of sugarcane

| Treatment | Cane yield (tonnes/ha) | | | Sugar yield (tonnes/ha) | | |
|---|---|---|---|---|---|---|
| | 2007–09 | 2008–10 | Pooled | 2007–09 | 2008–10 | Pooled |
| $T_1$: Conventional furrow planting at 90 cm apart | 93.91 | 95.83 | 94.87 | 11.07 | 10.77 | 10.92 |
| $T_2$: Deep furrow (20 cm) planting at 90 cm apart covering setts with 2.5 cm of soil layer | 97.85 | 100.42 | 99.14 | 11.60 | 11.38 | 11.49 |
| $T_3$: Paired row furrow planting at 120 : 60:120 cm | 95.26 | 98.77 | 97.02 | 11.25 | 11.13 | 11.19 |
| $T_4$: Paired row deep furrow (20 cm) planting at 120: 60:120 cm covering setts with 2.5 cm of soil layer. | 99.63 | 102.82 | 101.23 | 11.88 | 11.64 | 11.76 |
| $T_5$: Modified trench planting at 120 cm apart placing setts across the furrow and covering them with 2.5 cm of soil layer | 118.70 | 121.66 | 120.18 | 14.34 | 14.16 | 14.20 |
| S Em ± | 1.11 | 1.89 | 1.60 | 0.30 | 0.31 | 0.32 |
| C D ($P$ = 0.05) | 3.43 | 5.83 | 4.93 | 0.94 | 0.95 | 0.98 |

Table 3 Effect of planting methods on juice quality parameters at harvest of sugarcane (pooled data of two years)

| Treatment | Brix (%) | Purity (%) | CCS (%) |
|---|---|---|---|
| $T_1$: Conventional furrow planting at 90 cm apart | 19.21 | 87.28 | 11.52 |
| $T_2$: Deep furrow (20 cm) planting at 90 cm apart covering setts with 2.5 cm of soil layer | 19.27 | 87.53 | 11.60 |
| $T_3$: Paired row furrow planting at 120 : 60:120 cm | 19.24 | 87.29 | 11.54 |
| $T_4$: Paired row deep furrow (20 cm) planting at 120: 60:120 cm covering setts with 2.5 cm of soil layer. | 19.28 | 87.62 | 11.63 |
| $T_5$: Modified trench planting at 120 cm apart placing setts across the furrow and covering them with 2.5 cm of soil layer | 19.51 | 88.08 | 11.86 |
| S Em ± | 0.06 | 0.30 | 0.06 |
| C D ($P$ = 0.05) | 0.19 | NS | 0.20 |

Table 4 Economics of different planting methods (mean data of two years)

| Treatment | Cost of cultivation (₹/ha) | Net returns (₹/ha) | B:C ratio |
|---|---|---|---|
| $T_{1:}$ Conventional furrow planting at 90 cm apart | 56319 | 119340 | 2.10 |
| $T_{2:}$ Deep furrow (20 cm) planting at 90 cm apart covering setts with 2.5 cm of soil layer | 61981 | 121688 | 1.94 |
| $T_{3:}$ Paired row furrow planting at 120 : 60:120 cm | 56657 | 123285 | 2.15 |
| $T_{4:}$ Paired row deep furrow (20 cm) planting at 120: 60:120 cm covering setts with 2.5 cm of soil layer. | 62301 | 125354 | 1.99 |
| $T_{5:}$ Modified trench planting at 120 cm apart placing setts across the furrow and covering them with 2.5 cm of soil layer | 68192 | 154436 | 2.23 |

Rates:2007–09 Sugarcane – ₹ 140/100 kg, Sugarcane top – ₹ 45/100kg
2008–10 Sugarcane – ₹ 220/100 kg, Sugarcane top – ₹ 50/100 kg

*Economics*

The cost of cultivation was higher in modified trench method of planting due to higher seed cane rate (80 quintals/ ha) than the other planting methods (60–70 q/ha) (Table 4). The expenditure incurred on seed cane and its preparation under modified trench method was 30% of the total cost of cultivation as against slightly lower value in rest of the planting methods. However, net returns and cost: benefit ratio obtained from different planting methods clearly revealed that it was the highest under modified trench method of planting. It thus indicated that the $T_5$ treatment exhibited a net returns and B: C ratio of ₹ 154 436/ha and 2.23 which were higher to the tune of 18.63 and 10.86, 20.17 and 3.59, 21.20 and 13.00 and 22.73 and 5.83% under $T_{4,}$ $T_{3,}$ $T_2$ and $T_1$ treatments, respectively. The higher profit margin under modified trench method was virtually due to increase in the production of sugarcane (18.72%) as minimum to the maximum of 27.01% as compared to other planting methods, and thus resulted a profitable planting method even after slightly higher cost incurred on its cultivation.

The study thus concluded that the modified trench method of planting ($T_5$) offers benefit in terms of producing higher yields of cane and sugar over other conventional methods of planting and that would be worth adopting by farmers for increased sugarcane productivity in sub-tropical India.

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