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Enhancing productivity of sugarcane (*Saccharum* spp. hybrid complex) by optimizing sub-soiling and preparatory tillage operations in east coast zone of India

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ABSTRACT

A field experiment was conducted at the Sugarcane Research Station, Nayagarh, Odisha, for two consecutive seasons *i.e.* 2009-10 & 2010–11 to enhance the productivity of sugarcane through sub-soiling and preparatory tillage operations in east coast climatic conditions of Odisha. Experimental results clearly indicated that the cane yield was significantly higher (96.27 t/ha) under the treatment of A_2B_2 (sub-soiling at 1.0 m distance along with preparatory tillage operations involving 2 harrowing) as compared to other treatments in the test, but it was statistically at par with A_3 B_1 (sub-soiling at 1.5 m distance with 4 harrowing) (90.23 t/ha). The A_2B_2 treatment thus produced higher cane yield ranging from 6.27% (A_3B_1) to 23.06 % (A_3B_1 *i.e.* no sub-soiling but with 4 harrowing, a farmers' practice taken as control) in different treatments of the study. Thus, sub-soiling at 1.0 m distance alongwith 2 harrowing was found to be the optimum and worth adopting tillage practice for enhancing cane productivity in east coast climatic conditions of Odisha. Quality of cane was not affected significantly due to different treatments in the test, and thus, not reported.

Key words: Sugarcane, Sub-soiling, Tillage practices, Yield.

India is one of the largest producer of cane sugar next to Brazil with an area coverage of 4.96 million hectares producing around 337 million tones of sugarcane with productivity of 67.9 t/ha (Mohanty and Mishra 2011). In Odisha, the crop is grown in 37 thousand ha with an average productivity of 70.85 t/ha. Though the crop productivity is higher than the national average, however, it has been found static and moreover, declining in some places since the last five years which is mainly because of the negative impacts of soil compaction on productivity and sustainability of sugarcane plant-ratoon system. For higher sugarcane yields, providing optimum soil environment by reducing soil compaction is an essential pre-requisite since the crop remains in the field for about 2 to 3 years due to the practice of raising 1-2 ratoon crops. Soil compaction occurs due to in-field transport and labour movement for various field operations and irrigation (Sundara 2006). The effects of compaction include reduced soil aeration and infiltration of rainfall and irrigation (Bell *et al*., 2001), poor soil structure, and an increased soil strength and resistance to root penetration (MacGary and Bristow 2004). Deep ploughing of the field by breaking its hard pan through sub-soiling operations can reduce its susceptibility to compaction by reducing soil bulk density (Barzegar *et al*. 2000). Recaud (1997) reported that cane roots have the genetic capacity to penetrate very deeply into the soil where there are no physico-chemical limitations. It is a common belief that deep tillage is essential for good cane production; consequently, adoption of sub-soiling and cross harrowing has now become a pre-requisite for maintenance of fine seed bed. Rate of root growth is affected by soil properties such as temperature, aeration, pore size, pore continuity and mechanical impedance. Roots grow readily in well-drained soils where the pore diameter is larger than the growing root; otherwise, the root tips need extra energy to push soil particles aside and overcome penetration resistance (Vepraskas and Miner 1986). Thus, keeping aforesaid points in view the present study was carried out to optimize the suitable tillage practice for ensuring better productivity of the crop in the east coast zone of India.

MATERIALS AND METHODS

A field experiment was conducted at the research farm of Sugarcane Research Station, Nayagarh, Odisha, for two consecutive seasons *i.e.* 2009-10 & 2010–11. The experimental site was located at 20^0 54" 90' N latitude and 80^0 07" 56' E longitude. The soil of the experimental field was sandy loam in texture with low organic carbon content (0.48%) having slightly acidic (pH- 6.3) in reaction. The available N status of the soil was low (240 kg/ha), where as available P (11.2 kg/ha.) & K (137 kg/ha.) contents were in medium range of soil fertility. The experiment was laid out in randomized block design with three replications with sugarcane variety 'Co 87044' in the study. There were five sub-soiling treatments *i.e.* no sub soiling (A_1), sub-soiling at 1.0 m distance (A_2), sub-soiling at 1.5 m distance (A_3), cross sub-soiling at 1.0 m distance (A_4) and cross sub-soiling at 1.5 m distance (A_5) along with two preparatory tillage operations *i.e.* 4 harrowing (B_1) and 2 harrowing (B_2). The net plot size was 10.0 x 4.5

m^2 with 75 cm row to row spacing. The sub-soiling operations were done by a tractor drawn sub-soiler to a depth of 45 cm. The fertilizers and manures were applied as per the recommended dose *i.e.* 250 kg N, 100kg P_2O_5 & 60 kg K_2O per ha and 10 t FYM per ha. The crop was managed as per the standard package of practices of the region. The dates of planting and harvesting were 28.01.2009 and 18.12.2009 during 2009-10 and 03.02.2010 and 16.01.2011 during 2010-11, respectively. The observation on germination was recorded at 45 days after planting, whereas length of cane, single cane weight, number of millable canes and cane yield were recorded at harvest. The quality of cane was not affected significantly due to different treatments in the test, hence not reported in the results. The data of each crop season were statistically analyzed separately. The homogeneity of error variance was tested using Bartlett's x^2 test. As the error variance was homogeneous, pooled analysis was done according to Cochran and Cox (1957). Since the variation between two seasons was not significant, the mean data of two crop seasons are presented here for discussion. Various treatments were compared under randomized block design.

RESULTS AND DISCUSSION

Experimental results presented in Table 1 clearly revealed that at 45 days after planting, sub-soiling at 1.0 m distance (A_2) along with 2 harrowing (B_2) could register significantly the highest germination percentage (71.1%) followed by sub-soiling at 1.5 m distance (A_3) with 4 harrowing (B_1) which recorded 65.4 % germination of cane buds. Both the treatments were at par and were statistically superior to other tillage operations. The higher germination percentage observed under the above treatments was due to pulverized and improved physical condition of the soil (Ahmad and Giridharan, 2000). Good seed bed conditions as obtained through sub-soiling and harrowing in the above treatments are important for germination, and establishment of the crop, since plants require relatively loose and friable soil conditions for good root growth and development of cane plants. Observations on number of tillers revealed that A_2B_2 produced highest number of tillers per hectare (95.1 thousands/ha) through sub-soiling at 1.0 m distance with 2 harrowing closely followed by A_3B_1 (93.0 thousands /ha). Sub-soiling at 1.0 m distance (A_2) along with 4 harrowing (B_1) was the next best treatment with 91.4 thousands tillers/ha. Higher number of tillers obtained in the above treatments was attributed mainly because of higher germination percentage, and this is the basic requirement for obtaining higher initial stand establishment in sugarcane growing.

The length of cane recorded at harvest was found to be the highest (2.7 m) in the treatment where the soil was pulverized with sub-soiling at 1.0 m distance (A_2) along with 2 harrowing (B_2) with highest single cane weight of 1.73 kg. The treatments next in order were A_2B_1 (sub-soiling at 1.0 m distance along with 4 harrowing) and A_3B_1 (sub-soiling at 1.5 m distance with 4 harrowing) with mean cane length of 2.5 m each. The single cane weights were 1.53 and 1.55 kg in A_2B_1 and A_3B_1, respectively. The highest number of millable canes were also produced (93.67 thousands /ha) in the treatment where the soil was manipulated at 1.0 m distance with 2 harrowing (A_2 B_2), followed by sub-soiling at 1.5 m distance (A_3) with 4 harrowing (B_1) which recorded 86.17 thousands / ha. The cane yield was the highest (96.27 t/ha) with sub-soiling at 1.0 m distance (A_2) along with 2 harrowing (B_2) and was at par with sub-soiling at 1.5 m distance (A_3) with 4 harrowing (B_1) with a cane yield of 90.23 t/ha. Both these treatments were statistically superior to all other tillage management practices. The treatment next in order was A_2B_1 (sub-soiling at 1.0 m distance along with 4 harrowing) which produced cane yield of 88.47 t/ha. The higher cane yield under the above treatments was primarily due to improved soil porosity, reduced soil compaction and enhanced root penetration for vigorous growth and development of cane plants. With adoption of deep cultivation and tillage practices in sugarcane growing, root tips of cane plants penetrate easily into the soil and do not need extra energy to push soil particles aside (Wagner *et al*. 1995). The above treatments thus improved

Table 1 Effect of tillage practices on yield attributes and cane yield (pooled data of two years (2009-10 & 2010-11)

Treatment	Germination (%) at 45 DAP	Tillers at 120 DAP ('000/ha)	Cane length (m)	Single cane weight (kg)	NMC ('000/ha)	Cane yield (t/ha)
A_1B_1	52.0	86.6	2.0	1.07	70.40	74.07
A_1B_2	58.7	87.1	2.1	1.08	82.23	85.57
A_2B_1	60.2	91.4	2.5	1.53	81.73	88.47
A_2B_2	71.1	95.1	2.7	1.73	93.67	96.27
A_3B_1	65.4	93.0	2.5	1.55	86.17	90.23
A_3B_2	56.0	87.6	2.3	1.31	81.10	84.57
A_4B_1	57.9	89.3	2.1	1.43	82.37	83.73
A_4B_2	56.1	88.0	2.1	1.37	83.23	85.47
A_5B_1	55.8	86.1	2.4	1.40	75.80	82.43
A_5B_2	56.0	87.4	2.4	1.40	76.63	82.67
CD (P=0.05)	5.97	9.12	0.23	0.17	8.15	4.25

the growth and development of cane plants leading to higher cane productivity as compared to other tillage practice where deep cultivation practices were not adopted (A_1B_1). Thus, sub-soiling at 1.0 m distance along with 2 harrowing was found to be the optimum tillage practice for obtaining higher cane productivity in the east coast climatic conditions of Odisha. Quality of cane was not affected significantly due to different treatments in the test, hence not reported in the text.

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