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RESEARCH ARTICLE

Assessing Potentiality of Bud Chip Technology on Sugarcane Productivity, Profitability and Sustainability in Real Farming Situations Under South East Coastal Plain Zone of Odisha, India

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Abstract Sugarcane (*Saccharum* spp. hybrids) is planted by pieces of cane stalk known as cane setts. This method of conventional sugarcane propagation in India has now become expensive as the cost of seed cane material used and quantity of seed material required for such planting accounts for around 20 % of the total cost of cultivation. An alternative way of using only bud chip holds promise to reduce the huge seed cane material in commercial sugarcane planting. In this context, an on-farm trial in a participatory mode at five farmers' fields was conducted consecutively during 2013–2014 and 2014–2015 cropping seasons at Ganjam district in Odisha with a view to assess the advantages of bud chip technology of cane cultivation over conventional sugarcane planting. The results of on-farm field trial indicated that sugarcane cultivation by bud chip technology produced cane yield of 106.8 t/ha which was 13.86 % higher than that of conventionally planted cane crop (92 t/ha). The cost of cultivation was Rs. 108,680/ha ($1618.79/ha) in conventional cane cultivation as against Rs. 91,390/ha ($1361.25/ha) under bud chip technology. Bud chip technology produced 32.63 % higher net returns than that obtained from of conventional sugarcane cultivation of Rs. 107,520/ha ($1601.51/ha). Sugarcane planting by bud chip technology has thus proved to be more productive with reduced cost on planting material since it fetched more net returns per unit area and time, and would be a better option for the farmers of south east coastal plain zone of India.

Keywords Sugarcane · Bud chip technology · Conventional planting method · Yield · Sustainability

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Introduction

Sugarcane (*Saccharum* spp. hybrids) crop possesses the potentiality of converting solar energy into sugars and other renewable sources of energy by virtue of its unique C_4 photosynthetic pathway. In India, it is grown in an area of 5.025 m ha with a total production of 342.56 m t of sugarcane and 26.5 m t of sugar with cane productivity of 68.1 t/ha (Naik et al. 2013). It is propagated commercially by planting pieces of cane stalk known as seed cane setts or seed cane. For commercial cultivation, a huge quantity (6–8 t/ha) of cane stalk cuttings having two to three bud pieces (25–30 cm long segments) are required for planting in one ha of field which cost about 22 to 25 % of the total production cost (Srivastava et al. 1981). Therefore, one of the major items of expenses incurred in sugarcane production is the huge quantity of seed cane material required for its planting. Reducing the seed cane quantity by way of introducing bud chip technology would be the best alternative to cut down the cost and accordingly enhance the returns and sustain sugarcane growing particularly in

Odisha where its cultivation is primarily done by small and marginal farmers (Mohanty and Nayak 2011).

In coastal Odisha, sugarcane is the most preferred crop especially for small and marginal land holding farmers (Mohanty et al. 2014). Bud chip technology of sugarcane growing has been preferred by many farmers particularly farm women because of drudgery reduction and easy-to-do-planting operations viz., bud chipping, placing bud chips in coco-pith-filled plastic cone trays, nursery raising, transplanting of settlings in furrows etc. Sugarcane cultivation by single bud chip technology can improve soil rhizospheric environment, root growth and the nutrients availability in soil due to microbial abundance and diversity besides saving of water, if drip irrigation is adopted (Ramamoorthy and Ramanujam 1993). Therefore, bud chip technology has attracted the attention of large number of sugarcane farmers, development workers in government and sugar sector for its large-scale promotion and adaptation. In light of above, the present on-farm trial was conducted to assess the potentiality of bud chip technology on sugarcane productivity, profitability and sustainability in real farming situations under south east coastal plain zone of Odisha at farmers' fields in a participatory mode during 2013–2014 and 2014–2015 cropping seasons comparing its performance with conventional method of planting.

Materials and Methods

An on-farm trial in a farmers' participatory mode was conducted for the two consecutive cropping seasons of 2013–2014 and 2014–2015 at *Giria* village under *Hinjilicut* block of Ganjam district in south east coastal plain zone of Odisha (India). The main objective was to find out the biologically most efficient, suitable, feasible and sustainable planting technique in sugarcane cultivation in the farmers field. The soil of the experimental field was clay loam in texture with medium organic carbon content (0.547 %) having slightly acidic (pH 6.07) in reaction, low in available nitrogen (138.7 kg/ha) and medium range of phosphorus (14.31 kg/ha.) and potassium (151.81 kg/ha.). Soil samples from five farmers' fields at 0–15 cm soil depth were collected for status of available plant nutrients before planting of sugarcane crop. These samples thus collected were pooled together and a representative homogeneous sample was analysed for determination of organic carbon (Walkley and Black method), available N ($KMnO_4$ method), 0.5 M sodium bicarbonate ($NaHCO_3$, pH 8.5)—extractable P and 1 N, NH_4OAC-extractable K, as per procedure described by Jackson (1973). The plot size was kept at 500 m^2 for each individual farmer field during both the cropping seasons. Single bud chip technology was thus assessed and compared for cane yield increments and economic returns with that of conventionally planted crop at all the five locations during both the years of experimentation.

In bud chip technology, the bud chips were cut out from upper portion of seed canes of sugarcane variety - Co 86249 using a locally fabricated bud chipper machine and then placed in the nursery beds on 7 January, 2013 and 17 January, 2014. All the bud chips were dipped in the slurry of 2.5 kg *Trichoderma* culture and 10 L of cow urine mixed in 50 L of water for 30 min. Approximately, 13,500 bud chips/ha were used for planting in the farmers' field. The plot size was kept at 500 m^2 for each individual farmer field during both the cropping seasons. The above-mentioned bud chips were then after implanted facing buds upward in 270 numbers of plastic trays each having 50 cones and half filled with mixture of well-rotten coco pith and 50-kg well-decomposed farm yard manure in 1:1 ratio. After that all the bud chips were completely covered with mixture of coco-pith and decomposed farm yard manure. These trays were placed one above the other and at the last, an empty tray was put upside down on the top of the stack with a view to maintain the humidity inside the trays. In this method, the eight sets of trays were arranged and wrapped tightly with black polythene sheet and kept in this way to produce optimum temperature (28–32 °C) and good humidity (80–90 %) around implanted bud chips. These bud chips sprouted after 7 days of implantation were removed from the polythene sheet and then kept them side by side on the field to sprinkle water. Recommended doses of N, P_2O_5 and K_2O fertilizers were given at 250: 100: 60 kg per ha and applied as per recommended package of practices. Before transplanting of bud chip technology grown plantlets in the field, chlorpyriphos 50 % EC was applied at 2 litres/ha to control the incidence of termite and early shoot borer. Before transplanting of the bud chip technology grown plantlets, well-decomposed farm yard manure at 20 tonnes/ha was mixed up with 1/3rd of total recommended dose of N, full doses of phosphorous and half of total K fertilizers and were applied in the furrows following a light irrigation. Twenty-seven days old plantlets as grown through the technique were transplanted in the farmers' fields on 3 February, 2013 and 11 February, 2014 at a spacing of 120 × 60 cm spacing. As a precautionary measure, pre-emergence herbicidal application of Atrazine at 2 kg a.i./ha at 2 days after planting (DAP) and two hand weedings at 60 and 90 DAP were done to manage the incidence of weeds. Remaining 2/3rd dose of N was applied as top dressing in two equal splits at proper soil moisture, one at the start of tillering and rest one with remaining dose of K at 90 DAP along the furrows after carrying out intercultural operations. At 75 DAP, *Azotobacter* and phosphorus solubilizing bacteria each at 5 kg/ha were mixed thoroughly with 0.25 t of well-decomposed farm yard manure and applied to the field accordingly. The crop was harvested on 7 February, 2014 and 22 January, 2015. All agronomical packages of practices were followed to raise the crop in both the cropping seasons. Observations on sugarcane growth, yield attributes, and cane yield were recorded at the appropriate stages of sugarcane crop, and compared accordingly after working out economics of both the techniques of sugarcane cultivation.

In a focus group discussion with farmers of the village, six dimensions of sustainability indices (Yadav et al. 2007) for agricultural viz., technological appropriateness, economic viability, environment friendly, socio-cultural compatibility and adaptability were discussed and agreed upon by the farmers to assess the sustainability of the both planting systems of sugarcane cultivation on which participatory on-farm trials were undertaken. A matrix ranking exercise with five selected farmers was done. In this exercise, each farmer was asked to weigh using a scale of 1 to 5 in every sustainability dimension for both the planting techniques under study. The total sustainability score for the respective planting technique was calculated by adding scores obtained against the components of sustainability dimension. Finally, on the basis of sustainability score, planting techniques were ranked accordingly.

Results and Discussion

Plant Population

Data on per cent survival of seedlings developed through bud chip technology and percentage cane buds germination in conventionally planted crop were compared and are presented in Table 1. The results showed that the seedling survival rate was 92.4 % in bud chip technology as compared to only 52.75 % bud germination in conventional method, creating a marked difference in initial plant population density which is ultimately responsible for higher number of millable canes in bud chip technology as compared to conventional method. Moreover, this technique also provides scope for gap filling with nursery raised seedlings which helps to ensure the initial optimum plant stand in the field after transplantation.

Growth and Yield Attributes

Data given in Table 1 indicate that bud chip planting technology produced markedly higher number of shoots/clump (7.5) at 120 days after planting (DAP) and number of tillers (‘000/ha) (97.24) at 120 DAP as compared to 4.5 and 89.46, respectively, obtained under conventional method of sugarcane planting. Uniform growth of initially emerged higher number of shoots obtained under bud chip planting technology paved the way for higher number of tall, thick and heavy millable canes compared with the conventional method of planting. This may be attributed to the fact that uniform initial planting density with better availability of natural resources and nutrition to the crop under bud chip method of planting provided optimum plant population as compared to the crop raised under conventional method of planting. Length and girth of cane were also higher in bud chip planting technology as compared to crop raised by planting of three bud setts. Length and girth of canes in bud chip technology were 285 and 3.1 cm, respectively, as compared to 260 and 2.9 cm in conventional method of planting. Initial higher plant population on account of optimum spacing must have enjoyed the benefits of conjunctive use of chemical and bio-fertilizers at the tillering phase which paved the way for higher yield attributing characters in bud chip planting technology (Mohanty 2014).

Yield

Similarly, number of millable canes were also higher (94.85 ‘000/ha) in bud chip technology as compared to conventionally planted crop (85.26 ‘000/ha) which clearly endorses the result of higher number of millable

Table 1 Growth and yield of sugarcane grown through bud chip technology and conventional planting methods (Mean of 2013–2014 and 2014–2015 cropping seasons)

Treatments	Germination of cane buds (%) at 45 DAP	Number of shoots/clump at 120 DAP	Number of tillers (000/ha) at 120 DAP	Length of cane (cm)	Girth of cane (cm)	Weight of cane (kg)	Number of millable canes (000/ha)	^{0}Brix	Cane yield (t/ha)
Conventional 3 bud setts planting	52.75	4.5	89.46	260	2.9	1.25	85.26	17.0	92.0
Bud chip method of planting	92.4	7.5	97.24	285	3.1	1.36	94.85	18.5	106.8

Table 2 Economics of sugarcane cultivation in bud chip and conventional methods of sugarcane planting (mean of 2013–2014 and 2014–2015 cropping seasons)

Sr. no.	Particulars of sugarcane cultivation	Bud chip technology of sugarcane planting			Conventional method of sugarcane planting		
		Units	Per unit cost (Rs.)	Total (Rs.)	Units	Unit cost (Rs.)	Total (Rs.)
1	Land preparation (ploughing days)	12	500 ($7.45)	6000 ($89.37)	12	500 ($7.47)	6000 ($89.37)
2	Farm yard manure (t)	20	12,000 ($17.84)	24,000 ($357.48)	20	12,000 ($17.84)	24,000 ($357.48)
3	Seed cane (t)	0	0	0	10	2250 ($33.51)	22,500 ($335.14)
4	Hiring charges of plastic cone trays and bud chipper	25	140 ($2.09)	3500 ($52.13)	0	0	0
5	Cost of coco pith/coir dust (in bags)	10	80 ($1.19)	800 ($11.92)	0	0	0
6	Scooping of bud chips (in man days)	10	200 ($2.98)	2000 ($29.79)	0	0	0
7	Bud/sett treatment (in man days)	3	200 ($2.98)	600 ($8.94)	3	200 ($2.98)	600 ($8.94)
8	Furrows opening (ploughing days)	3	500 ($7.45)	1500 ($22.34)	4	500 ($7.45)	2000 ($29.79)
9	Planting operation (in man days)	15	200 ($2.98)	3000 ($44.69)	10	200 ($2.98)	2000 ($29.79)
10	Bio-fertilizers (kg)	10	40 ($0.60)	400 ($5.96)	0	0	0
11	Crop protection measures	1	1500 ($22.34)	1500 ($22.34)	1	1500 ($22.34)	1500 ($22.34)
12	Inorganic fertilizers (NPK 250:100:60/ha)	–	–	10,000 ($148.95)	–	–	10,000 ($148.95)
13	Herbicide (Atrazine) (kg)	2	75 ($1.12)	150 ($2.23)	0	0	0
13	Intercultural operations 2 (in man days)	120	200 ($2.98)	24,000 ($357.48)	120	200 ($2.98)	24,000 ($357.48)
14	Detrashing, wrapping and propping (in man days)	100	200 ($2.98)	20,000 ($297.9)	108	200 ($2.98)	21,600 ($321.73)
15	Harvesting and detrashing and transportation by human labour up to truck (in man days)	230	200 ($2.98)	46,000 ($685.17)	238	200 ($2.98)	47,600 ($709.0)
16	Irrigation	17	500 ($7.45)	8500 ($126.61)	15	500 ($7.45)	7500 ($111.71)
	Total cost of cultivation (Rs./ha)	–	–	151,950 ($2263.30)	–	–	169,300 ($2521.72)
	Gross return (Rs./ha)	–	–	236,250 ($3518.94)	–	–	200,250 ($2982.72)
	Net Return (Rs./ha)	–	–	84,300 ($1255.65)	–	–	30,950 ($461.0)

canes/clump under bud chip technology. Average cane weight of 500 randomly selected canes per plot was 1.36 kg in bud chip technology as compared to 1.25 kg in conventional method of planting. Higher initial plant population along with higher yield attributing characters resulted in higher cane yield of 106.80 t/ha in bud chip technology as compared to 85.26 t/ha under conventional three bud setts planting.

Economics

Economics worked out for bud chip technology and conventional method of planting clearly indicated that the total cost of cultivation was Rs. 108,680/ha ($1618.79/ha) in conventional cane farming which reduced to Rs. 91,390/ha ($1361.25/ha) when the crop was grown by bud chip technology. After harvesting the crop, the cane yield thus obtained was sold at Rs. 2350/t ($35/t) which provided a gross return of Rs. 250,980/ha ($3737.01/ha) in bud chip technology of cane cultivation as compared to Rs. 216,200/ha ($3220.30/ha) in conventionally planted crop. The higher cane yield (106.80 t/ha) from bud chip technology and reduced cost of cultivation helped to realize higher net return of Rs. 159,590/ha ($2377.09/ha) as against Rs. 30,590/ha ($461/ha) in conventionally planted sugarcane crop. The major difference in cost of cultivation was due to the enhanced cost of seed cane material (10 t/ha) in conventional method of sugarcane planting. Cane quality in terms of ^{0}Brix was also higher in sugarcane plants raised through the bud chip planting method compared with conventionally grown crop (Table 2). Uniform growth of cane plants under bud chip technology got optimum time for their maturity and accordingly exhibited higher ^{0}Brix values.

Sustainability of Technology

The pooled scores of five farmers for each of the sustainability dimensions against every planting technique are

Table 3 Sustainability score of five farmers on sugarcane cultivation in bud chip and conventional methods of sugarcane planting (mean of 2013–2014 and 2014–2015 cropping seasons)

Sr. no.	Sustainability dimension	Sugarcane planting by bud chip method	Sugarcane planting by 3-bud setts method	Total score	Rank
1	Technological appropriateness	23	16	39	III
2	Economic viability	23	20	43	II
3	Environmental soundness	18	17	35	VI
4	Socio-cultural compatibility	20	16	36	V
5	Productivity	19	16	45	I
6	Adaptability	19	18	37	IV
	Total score	122	103	225	
	Rank	I	II		

presented in Table 3. It is evident from Table 3 that the sugarcane planting by bud chip and conventional methods was ranked-I and II on the sustainability index with a total sustainable score of 122 and 103, respectively. Farmers rated sugarcane planting by the bud chip method as the most sustainable planting method in their system due to good fitness in terms of economic viability, productivity, technological appropriateness, adaptability, socio-cultural compatibility and environment soundness in local agricultural production system.

Conclusion

On-farm trial results clearly indicated that the bud chip technology provided higher cane yield (106.80 t/ha) as against 92.00 t/ha under conventionally planted crop by 3-bud setts, which was higher by 13.86 % over conventional method of planting. The study thus suggests that the bud chip technology of sugarcane planting is worth adopting particularly by the small and marginal farmers in South East Coastal Plain Zone of Odisha since it is not only high yielding but also cost effective and sustainable.

Compliance with Ethical Standards

Conflict of interest Authors hereby certify that there is no any conflict of interest in submitting and publishing our research paper entitled "Assessing Potentiality of Single Bud-Chip Planting Technology on Sugarcane Productivity, Profitability and Sustainability in Real Farming Situations under South East Coastal Plain Zone of Odisha" authored by J. R. Patnaik. S. N. Singh. Debasis Sarangi. P. K. Nayak in Sugar Tech.

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