RESEARCH ARTICLE

PERFORMANCE FEASIBILITY AND ECONOMIC VIABILITY OF SUGARCANE BUDCHIP SEEDLING PLANTER IN ANDHRA PRADESH STATE, INDIA

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ABSTRACT

Sugarcane is a major commercial crop which requires considerable labour force for planting. The presently followed planting method that uses stalk cutting or setts is gradually becoming uneconomical as the cost of "seed cane" used for planting accounts for over 20% of the total cost of production, besides being labour intensive. The recent technique of transplanting sugarcane budchip seedlings is gaining popularity as it reduces seed cost in comparison with the present sett method of planting. Manual transplanting of sugarcane seedlings in dry soils is a slow, inaccurate, expensive and tedious task. Hence, the performance of a tractor mounted two-row sugarcane budchip seedling planter for planting of seedlings raised from sugarcane buds in pro trays was evaluated in comparison with the conventional method of planting at the Regional Agricultural Research Station, Anakapalle, Visakhapatnam district, Andhra Pradesh State, India. The field capacity of the budchip planter was found to be 0.16 ha/h. The biometric parameters, viz. height, diameter and yield of cane obtained from seedlings planted with budchip seedling transplanter were on par with those under traditional method of planting; however, root spread area and single cane weight differed significantly between the two methods. Similarly, juice quality in terms of Brix and sucrose (%) at harvest of sugarcane seedlings planted with budchip planter was on par with that of cane planted by conventional method. Economic analysis revealed that cost of planting per ha was R 7,350 with budchip seedling planter as against Rs. 15,400 with traditional method of planting. The savings in labour cost, seed quantity and planting time with budchip seedling planter method were to the tune of 52, 75 and 58%, respectively as compared to conventional sett method of planting.

Key words : Budchip seedling planter, sugarcane seedlings, conventional planting, labour cost

Introduction

India is the largest consumer and second largest producer of sugar in the world next to Brazil. As the primary sugar yielding crop, sugarcane occupies a very prominent position among the agricultural crops of India spreading across both tropics and subtropics. Sugarcane is the second most important agro-industrial crop of the country and is the only raw material for nearly 538 sugar mills (2014-15) producing about 28 Mt of sugar annually. The area under sugarcane in India during 2014-15 was 5.31 Mha as against 5.34 Mha during 2013-14, showing a declining trend. Sugarcane production is highly labour intensive requiring about 3300 man hours for various operations (Murali and Balakrishnan 2012) and labour wages account for 60% of the total cost of cultivation (Yadav et al. 2003). Most of the cane operations are carried out manually and the use of machinery is generally limited to field preparation. Due to high cost of labour and inputs, the area under sugarcane in Andhra Pradesh State is showing a decreasing trend and the average sugarcane yields have always been hovering between 74.9 t/ha (2004-05) and 66 t/ha (2014-15) (Anonymous 2016). However, to obtain sustained potential yield, engineering

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inputs and efficient crop management have to play a major role.

Among the various operations required for sugarcane cultivation, seed bed preparation, planting, inter-culture, earthing-up and transportation are in semi-mechanized stage. In conventional planting prevailing in Andhra Pradesh, about 6 - 8 t/ha of seed cane is used as planting material which poses serious problems in transport, handling and storage. In addition, rapid deterioration reduces viability of the buds and their subsequent sprouting. A new method of planting using sugarcane budchip seedlings is gaining popularity, in which the bud along with a portion of nodal region is chipped off and planted in raised bed nurseries or polybags or pro trays filled with FYM, soil and sand. The seed material required under this technique is only 1.0 - 1.5 t/ha and besides other advantages (Werken 1991; McIntyre 1993; Sundara 1998; Singh et al. 2000; Yadav et al. 2003; Ismail and Ghattas 2009). However, manual transplanting of sugarcane bud chip seedlings in dry soil is tedious and laborious, in addition to other disadvantages (Splinter and Suggs 1959; Kavitha 2005; Ravindra Naik et al. 2013). To overcome these problems, mechanized planting of budchip seedlings was attempted in Egypt (Abdel-Mawla et al. 2014) and Coimbatore, India (Ravindra Naik et al. 2013). However, no detailed study on testing of mechanical sugarcane planter under coastal conditions is available. Hence, the performance of a tractor mounted mechanical two-row bud chip seedling planter was evaluated in comparison with conventional method of planting at the Regional Agricultural Research Station (RARS), Anakapalle, Andhra Pradesh.

Materials and methods

A field experiment was conducted in 2015 at RARS, Anakapalle, Visakhapatnam district, Andhra Pradesh (16°30'N latitude and 18°20' E longitude), with the variety 93 A145 (Sarada) developed at the RARS. Sarada is an early maturing variety possessing characteristics such as drought tolerance, resistance to red rot, tolerance to smut and good productivity (Anonymous 2014).

Preparation of sugarcane budchip seedlings

Sugarcane buds were taken from the bottom one meter portion of healthy 10-month old canes using a pneumatic budchip machine developed by the ICAR-Central Institute of Agricultural Engineering, Regional Centre, Coimbatore, Tamil Nadu. The extracted budchips (≈10 g each) were dipped in carbendazim 0.1% solution for 10 min, shade dried for 20 min, and planted in plastic pro trays. The trays were of 530 mm x 270 mm x 50 mm size containing 50 round cells with diameter of 50 mm at the top and 30 mm at the bottom, and depth of 50 mm which were filled with FYM, soil and sand at 1:1:1 ratio (Ravindra Naik et al. 2013). Planted trays were maintained in a shade net and seedlings were taken for transplanting at 15 cm height, i.e. about 20 days after planting.

Field performance evaluation of budchip seedling planter

The two-row tractor drawn sugarcane budchip transplanter (AG-TC210, 2 m chassis width, 350 kg total weight, Akay Fab Steel Systems (P) Ltd., New Delhi) evaluated in the field consists of a main frame which can be attached to standard three-point hitch arrangement of a tractor. The metering mechanism, operator's seat, furrow openers, soil openers and furrow closures are mounted on the main frame with necessary supports. The transplanter can plant approximately 90-100 plants per minute. The row-to-row distance can be adjusted from 45 to 110 cm while inter-plant spacing can be adjusted from 12 to 75 cm. In a plot of 16.9 m x 52.6 m size, the seed bed was prepared by two ploughings followed by roto tilling to make fine tilth and recommended dose of urea and super phosphate was broadcast. After fine tilth, soil was leveled to facilitate good performance of the budchip transplanter.

Operation of budchip seedling planter

The machine was calibrated before operating in the field. The seedlings were carefully removed from pro trays and placed in the sugarcane budchip planter seedling tray. A tractor of 45 HP was operated at a speed of 1.4 km/h choosing the best tractor gear (Ravindra Naik et al. 2013). Two persons seated on the rear of the equipment constantly dropped the seedlings through the holes of rotating metering device (Fig.1). While falling through the chute, due to combination effect of soil at the root base and parachuting effect of leaves, the root portion is always at the bottom and the tip of the seedling is on the top. During the movement of the tractor in the forward direction, shoe type soil opener opens the soil and seedling falls in the opened soil. After a small time lag, inclined rubber packing wheels pack the soil firmly around each plant. The inter-row spacing was kept at 150 cm and 60 cm (paired row) to facilitate intercultural operations with tractor operated rotavator. A plant-to-plant spacing of 30 cm was maintained by changing the gear ratio between power transmission mechanism and the ground wheel.

Fig. 1. Budchip seedling transplanter in operation

A field of the same size (16.9 m x 52.6 m) was prepared for comparative evaluation of conventional planting by following the procedure described above for budchip planter. The field was prepared by ploughing with tractor mounted mould board plough followed by roto tilling to make fine tilth. The soil was then leveled using tractor mounted leveling blade. Recommended dose of urea and super phosphate was broadcast before planting three budded setts.

Machine parameters

Machine parameters like field capacity (Ravindra Naik et al. 2013) and fuel consumption (Stevens 1982) were measured and recorded. For calculation of slip percentage, a mark was placed on the side of a rear wheel of the tractor before the test. The tractor with and without budchip seedling planter was operated with usual gear from the starting point to final set point in the field having 12% moisture content (dry basis). Then the number of revolutions taken by the tractor to reach the final set point from starting point with and without the budchip seedling planter was measured and the slip percentage was calculated using the formula given below:

$$\text{Slip percentage} = \frac{\text{No.of revolutions with load - No.of revolutions without load}}{\text{No.of revolutions with load}} \times 100$$

Soil moisture content and bulk density

Soil samples were collected randomly from four different locations at a depth of 0-30 cm for each treatment. The moisture content of the soil was determined on dry weight basis by keeping known weight of the soil sample in the oven at 105°C for 24 h. Bulk density of the soil on dry weight basis was determined using a core sampler (100 mm dia and 150 mm length) (Kumar and Tripati 2015). The soil parameters are presented in Table 1.

Table 1. Soil conditions in the experimental plots

Parameter	Status
Moisture % (dry basis)	12.0
Bulk density (g/cc)	1.32

Biometric parameters

Biometric parameters such as root geometry, cane height, diameter of the cane, single cane weight and yield were recorded in plots planted with budchip seedling planter and conventional method. At 150 DAP, sugarcane stools were inundated for 2-3 d and uprooted without any damage to root mass. The length of taproot and peripheral roots was measured and the root spread area was calculated as a product of both (Mukunda Rao et al. 2017). About 20 canes were selected at random from each plot at harvest and the diameter of the cane was measured using Vernier caliper at three different heights, viz. one foot above the bottom end, one foot below the top end and middle of cane, and the average calculated. Length of the 20 canes was measured using measuring tape and the average calculated. Cane yield was measured by harvesting the canes plot-wise leaving boundary rows and weight of the canes was recorded after detrashing for each treatment plot and the yield was worked out on hectare basis (Kumar and Tripati 2015).

Sugarcane juice quality analysis

Ten cane samples were collected at random, detrashed and the tops were removed at the point of breakage. The juice was extracted using a clean three roller power operated crusher with a minimum of 60% juice extraction within 12 h of harvest. Sugarcane juice quality parameters such as Brix and Sucrose (%) were measured using hand refractometer (Make: Atago; Model: PAL-1) and saccharimeter (Make: Anton paar; Model: MCP 500 Sucromat), respectively.

Economics

The total cost of operation of budchip planter for transplanting of budchip seedlings was calculated. The fixed and variable costs for operating the budchip planter with tractor per hour were calculated (Anonymous 1983). The performance was compared with the conventional planting in terms of savings in labour cost, seed and time.

Statistical analysis

The data were analyzed using two sample t-test and significant differences were evaluated at 5% probability level (Gomez and Gomez 1984). All the statistical calculations were done using Microsoft Excel (Anonymous 2003).

Results and discussion

The performance evaluation of tractor drawn two-row budchip transplanter for transplanting of budchip seedlings is given in Table 2. The field capacity of the budchip planter was found to be 0.16 ha/h at 75% field efficiency.

Table 2. Performance of two-row tractor drawn budchip planter

Parameter	Status
Slip % at 12% moisture content	4.0
Field capacity (ha/h)	0.16

Root spread area at 150 days was significantly higher in budchip planter method (1840 cm^2) than in conventional planting (1664 cm^2) (Table 3). Cane diameter and height in budchip planter method (2.76 cm and 2.55 m) were not significantly different from those in conventional planting (2.65 cm and 2.47 m). Single cane weight at harvest was significantly higher in budchip planter method (1.04 kg) than in conventional method of planting (0.85 kg).

Cane yield in budchip planter method (68.2 t/ha) was not significantly different from that in conventional planting (67.6 t/ha). Brix and sucrose at harvest in budchip seedling planter method (21.6 and 19.6%) were not significantly different from those in conventional planting (21.2 and 19.0%). The results indicated that biometric parameters of budchip planter were on par with those of conventional planting, except root spread area and single cane weight. Higher single cane weight higher in budchip planting method than in conventional planting with no corresponding yield difference may be due to higher number of non-malleable canes (NMCs) recorded in conventional planting than in budchip planting method.

The economic analysis of sugarcane budchip planter over conventional planting (Table 4) revealed that the cost of operation of budchip seedling planter along with tractor was Rs. 600. The cost of planting per hectare was Rs. 7350 with budchip seedling planter whereas it was Rs.15,400 with conventional method of planting at wage rate of Rs. 300 and Rs. 200 per day for men and women respectively. The savings in labour cost, quantity of seed and planting time were found to be 52, 75 and 58%, respectively over conventional planting.

Table 3. Biometric and juice quality parameters at harvest in plots planted using budchip planter and conventional method

Parameter	Budchip planter	Conventional planting
Root spread area at 150 days (cm^2)*	1840.0 ± 12.1	1664.0 ± 14.3
Cane diameter (cm)^{ns}	2.76 ± 0.15	2.65 ± 0.35
Cane height (m)^{ns}	2.55 ± 0.14	2.47 ± 0.20
Single cane weight (kg)*	1.04 ± 0.04	0.85 ± 0.04
Yield (t/ha)^{ns}	68.20 ± 6.27	67.60 ± 6.55
Brix^{ns}	21.6 ± 1.1	21.2 ± 1.0
Sucrose (%)^{ns}	19.60 ± 0.37	19.00 ± 0.40

* $P<0.05$; ^{ns} $P>0.05$

Table 4. Economics of conventional planting vis-a-vis mechanical planting

Operations	Method of Planting					
	Conventional planting			Budchip Planter		
	Men*	Women	Total	Men	Women	Total
Harvesting and transportation of seed material	10	20	7000	2	4	1400
Removal of budchips, filling pro trays and transportation of seedling trays to field	-	-	-	2	8	2200
Opening of furrows with tractor	-	-	1500	-	-	-
Cutting, spreading and planting of three budded setts, and irrigation	13	15	6900	-	-	-
Hire charges of tractor with budchip planter for 6.25 h @600 per hour	-	-	-			3750
Total cost			15400		-	7350
Savings in labour cost	15400 – 7350 = 5600 (52%)					
Seed material requirement	10.0 t/ha			2.5 t/ha		
Savings in seed quantity	10.0 – 2.5 = 7.5 (75%)					
Time taken for planting	15.00 h			6.25 h		
Saving in time for planting	15.00 – 6.25 =8.75 (58%)					

* Labour charges for men = Rs. 300/- and women = Rs 200/- per day of 6 h

** Tractor with budchip planter hire charges = Rs.600 per hour

In conclusion, tractor drawn two-row sugarcane budchip seedling transplanter for planting of budchip seedlings grown in pro trays had the field capacity 0.16 ha /h at optimized speed of operation of 1.4 kmph. There were no significant differences in yield and quality parameters of sugarcane planted using budchip planter method and conventional planting except single cane weight and root spread area. Economic analysis of the budchip planter revealed a significant saving in labour cost, quantity of seed and time of planting due to budchip method over conventional planting.

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