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RESEARCH ARTICLE

Studies on Mechanisation of Planting of Sugarcane Bud Chip Settlings Raised in Protrays

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Abstract Sugarcane bud chip planting is the latest technique of sugarcane planting, wherein the bud along with a portion of the nodal region is chipped off and planted in protray with FYM soil and sand. Studies on mechanisation of the planting of settlings from sugarcane buds raised in portrays were carried out at Central Institute of Agricultural Engineering—Regional Centre, Coimbatore and Sugarcane Breeding Institute, Coimbatore and a tractor mounted two row mechanical planter for settlings raised from sugarcane bud chips was developed. It consists of mainframe which can be attached to standard three-point hitch arrangement of a 35 hp tractor. The metering mechanism, operator's seat, furrow openers, soil openers and furrow closers are mounted on the main frame with necessary supports. The optimum speed of operation was standardized as 1.4 km/h by experimentation where the missing percentage was 2.33 %. The field capacity of the equipment was 0.15 ha/h. The biometric parameters viz., diameter of the cane, cane height, single cane weight, juice content and yield of the mechanically planted sugarcane settlings were on par with the manually planted sugarcane settlings. The juice quality of sugarcane from mechanically planted settling in terms of brix, CCS, sucrose and purity was at par with sugarcane from manual planting of settlings at the time of harvest. Cost economic analysis of planting with mechanical planter showed 40 and 85 %, saving in cost and labour, respectively over manual bud chip settling planting.

Keywords Sugarcane · Settlings · Planter · Field capacity · Biometric parameters · Cost economics

Introduction

Sugarcane is an important cash crop of India. It is cultivated in an area of 5.025 mha with a total production of 342.56 mt of sugarcane and 26.5 mt of sugar in the year 2011–12 at an average productivity of 68.1 t/ha. The demand for sugar in the country by 2030 will be 36 mt for which the sugarcane production has to be 500 mt (Vijayan Nair 2012). This amounts to 40 % increase over the current production and has to be achieved through vertical improvement in productivity. Significant efforts have been made to increase sugarcane yield through varietal developments, control of pests and diseases, improved cultural practices etc. However, to obtain sustained potential yield, engineering inputs and efficient crop management have to play major role.

Sugarcane cultivation requires various operations like seedbed preparation, planting, interculture, earthing up, plant protection, harvesting, transportation and ratoon management. Planting, interculture, earthing up and transportation are in semi mechanized stage. The present commercially followed method of planting is by using stalk cuttings or setts and this method of cultivation is gradually becoming uneconomical as the cost of "Seed Cane" used for replanting accounts for over 20 % of the total cost of production. In conventional system prevailing in India, about 6–7 t seed cane/ha (nearly 10 % of total produce) is used as planting material, which comprises of about 25–30 cm stalk pieces

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having 2–3 buds. This large mass planting material poses a great problem in transport, handling and storage of seed cane and undergoes rapid deterioration thus reducing the viability of buds and subsequently their sprouting. Of late, a new method of planting with sugarcane bud chip settling is gaining popularity. Here the bud along with a portion of the nodal region is chipped off and planted in raised bed nurseries/polybags/protrays filled with FYM, soil and sand. Seed material required under this technique is only 1–1.5 t/ha and the remaining cane after taking bud chips can be sent for milling/jaggery making. It also facilitates easier handling and transportation. Selection of healthy buds, elimination of diseased and infected buds is easy thereby sett transmitted diseases and pests could be kept at a minimum. Although there are several advantages of planting the sugarcane by using bud chipping technique, it has disadvantages in terms of additional manpower required for planting of settlings from the bud chips.

Manual planting of sugarcane bud chip settling is very tiresome and laborious as the operation is done in a bending posture. This requires labour for pulling the settlings and planting them in the field. The studies on manual planting of bud settling plants have shown high labour requirement in a short period of time, weather hazards often causing farmers to miss the best planting period and resulting in low yield. The plant losses expected due to unavoidable human error during the planting operation resulting in non-uniformity of stands and the missing plants need to be reset and hence, extra labour is required (Splinter and Suggs 1959; Kavitha et al. 2005). Usually the irrigation channels for the planted bud chip settlings are formed after the planting is done. This involves additional labour and there are likely chances that the bud chip settlings may be disturbed. Labour shortage during peak season causes delay in planting and related operations, leading to drastic reduction in yields. Considering the above facts, studies were carried out on mechanization of planting of sugarcane bud chip settlings grown in protrays at Central Institute of Agricultural Engineering—Regional centre, Coimbatore in collaboration with Sugarcane Breeding institute, Coimbatore and a tractor mounted 2-row mechanical planter was developed.

Materials and Methods

Preparation of Sugarcane Bud Chips

Eight months old Co 99004 variety of sugarcane grown in the experimental research plot of Sugarcane Breeding Institute, Coimbatore in the year 2011 was used for investigations. Sugarcane buds were taken from the bottom 1 m portion of healthy cane, free from insects and diseases attach were taken out by using sugarcane bud chipping equipment developed by Central Institute of Agricultural Engineering, Regional centre, Coimbatore. The extracted bud chips were shade dried for 2–4 h. The shade dried buds were dipped in malathion 50 EC 0.1 % (2 ml/1 of water) and carbendazim 0.1 % (1 ml/1 of water) solution for 10 min and again shade dried. The pretreated sugarcane bud chips were planted in plastic protray filled with FYM, soil and sand at 1:1:1 proportion and grown in the glass house of Sugarcane Breeding Institute, Coimbatore. The size of each protray was 530 × 270 × 50 mm, round in shape containing 50 cells (10 × 5). The cell measurement was 50 mm ϕ at top, 30 mm ϕ at bottom and 50 mm in depth. The weight of each extracted sugarcane bud chip was 10–12 g. The height of settlings for planting was optimized at 15 cm after 35 days of planting (Annamalai et al. 2011).

Development of Tractor Drawn Two Row Mechanical Planter for Sugarcane Settlings Raised from Sugarcane Bud Chips

Based on the Tami Nadu Agricultural University model of vegetable planter (Kavitha and Duraisamy 2007), a tractor drawn two row mechanical planter for sugarcane settlings raised from sugarcane bud chips was developed with required modifications. The different parts of the mechanical planter are given below.

Main Frame

A frame was fabricated with 75 × 40 × 5 mm mild steel channel having a dimension of 1,800 × 1,600 mm. All components of the mechanical planter were assembled with the main frame in core alignment. A standard three-point hitch arrangement was provided for hitching the frame to the tractor. The metering mechanism, operator's seat, furrow openers, soil opener and soil closure were mounted on the main frame with necessary supports. The top link was made of 2 m.s. strips with a slot. For lower links, two high carbon steel rods of 25 mm diameter and 190 mm length for each side were provided.

Metering Mechanism

The circular metering mechanism consisted of two circular plates of 600 mm diameter mounted on a 25 mm diameter shaft (Fig. 1). It was designed on the basis of physiological characteristics of sugarcane bud chip settling nursery. The discs were kept at a distance of 60 mm with each other. The bottom plate was fixed and had a single hole with a diameter of 70 mm. The top plate was rotating, which had

Fig. 1 Metering mechanism

8 holes of 70 mm diameter, taking factor of design safety as 1.50. As and when, the operator places a plant in each hole on the top plate and as the plate rotates, the seedling will drop due to gravity when holes on the top and bottom plates coincide.

Design of Metering Mechanism

At a known speed of the machine (vm) and selected plant-to-plant distance between settlings (Ag), the frequency of rotation (rpm) of rotating metering mechanism of the machine is given by

$$n = (60 \times \mathrm{vm})/(Z \times \mathrm{Ag}) \qquad (1)$$

where n = number of revolutions of revolving magazine per min, vm = speed of the machine, m/s, Z = number of cell on revolving magazine, Ag = plant-to-plant distance between seedling, m.

The equation shows that frequency of rotation of the revolving magazine increases on increasing the speed of the machine.

Design of Drop Chute Pipe

Sugarcane settlings falling at the ground make an angle of 85–88° with the horizontal, and falls in the direction of travel of the machine. To make plant upright, the drop chute pipe was inclined by an angle of 15° to vertical. A parabolic cut was made at the bottom of the drop chute pipe. The height of the cut was 15 cm.

Power Transmission

The power for the metering unit was taken from ground wheel by means of chain and sprockets to the gear box (Fig. 2). The ground wheel (Fig. 3) was made of m.s. rod of 10 mm thickness and 730 mm diameter. Twelve lugs of 50 mm × 45 mm section were attached at the periphery of

Fig. 2 Power transmission mechanism in sugarcane bud chip settling planter

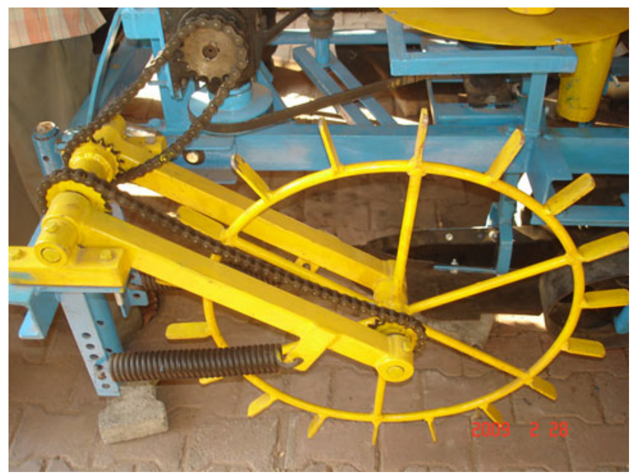

Fig. 3 Ground wheel in sugarcane bud chip settling planter

each of the ground wheel. In the power transmission from the gearbox, which encompassed a bevel gear with a pinion of 18 teeth, a horizontal shaft transmitted power to a vertical shaft through a bevel gear (1:1) assembly. The circular metering mechanisms were rotated by the vertical shaft. The ground wheels rotated a hub with sprockets attached on the ground wheel shaft axle, and power was transmitted through chain to another sprocket on the main shaft. The speed of planting was a function of both tractor speed and selected power train.

Soil Opener Shoe

Shoe type furrow opener was selected for Sugarcane bud chip settlings planter (Fig. 4). The width of the shoe was 120 mm (Kavitha and Duraisamy 2007).

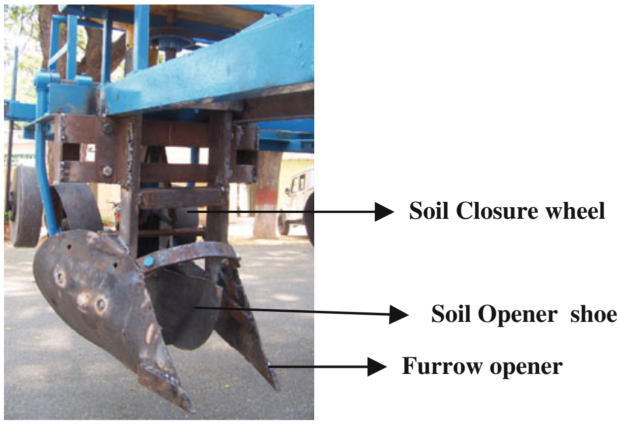

Fig. 4 Soil closure wheel, soil opener and furrow opener of sugarcane bud chip settling planter

Soil Closure Wheels

The soil covering wheel assembly consisted of two soil covering wheels of 570 × 75 mm, side mounted on a shaft inclined at 15° to the vertical (Fig. 4). The shaft was welded to the main frame through supporting plates. The distance between the two wheels at the bottom end was 95 mm and 175 mm at the top end. These were tilted at an angle of 75° with the horizontal.

Settling Holding Tray

To hold the settlings trays, a frame was fixed above the settling metering plate. The size of the tray is 620 mm × 1300 mm.

Operator's Seat

A pair of operator's seat was provided behind planting mechanism. Two persons could sit and feed the settlings in the opening of the circular metering mechanism, enabling planting of the sugarcane settlings.

Furrow Opener

To aid in irrigation after planting of settlings, a furrow opener was provided in front of the soil opener for forming irrigation channels on both sides of the settlings planted. It consists of a pair of wings, which was having a spacing of 200 mm at the front and 580 mm towards the wings (Fig. 4). A soil cutting tool was provided at the front of the furrow opener to aid in opening of the soil to form the furrows.

Evaluation of Metering Mechanisms for Sugarcane Bud Chip Settlings Planter

The two row tractor drawn sugarcane bud chip planter developed as described above, (Fig. 5) was evaluated for its performance in relation to efficiency of plantings (per cent missing), cost and field capacity.

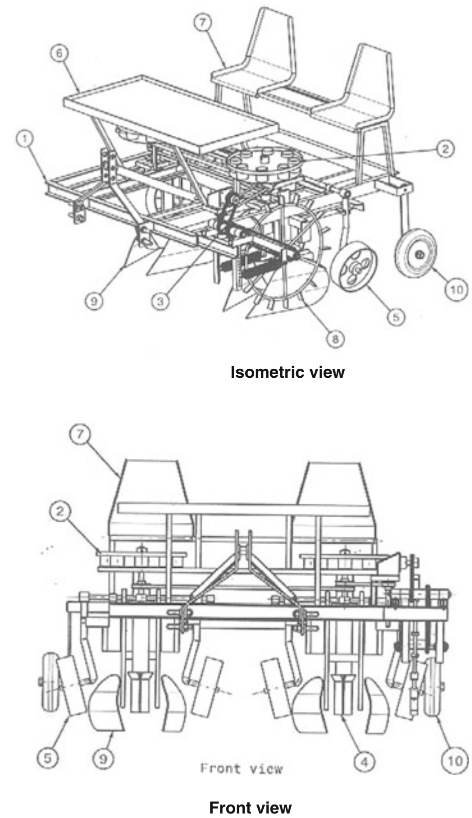

Fig. 5 Isometric and front view of two row tractor drawn mechanical planter for sugarcane bud chip settlings raised in protray. *1* Main frame, *2* metering mechanism, *3* power transmission mechanism, *4* soil opener, *5* soil closer wheels, *6* sugarcane bud chip settling holding tray, *7* feeding men's seat, *8* ground wheel, *9* furrow wheel, *10* depth control wheel

Efficiency of Planting (Per Cent Missing)

Different parameters affect the performance of a planter, one of which is machine forward speed. Machine travel speed is known to increase the operator feeding rate resulting in higher skips in feeding or missing (Suggs 1979; Way and Wright 1987; Ladeinde et al. 1995; Juric et al. 1997; Kavitha 2005; Kavitha and Duraisamy 2007).

Optimization of Speed of Operation of the Equipment

A laboratory test was conducted to obtain the percentage of plant missing for different machine speeds. The percentage of plant missing for the machine speed varying from 0.6 to 1.8 km/h was studied. The travel speed was optimized by the interaction between speed of operation of machine and the % plant missing during planting operation.

Laboratory Setup for Testing the Plant Missing

The machine was raised above the ground by four supports. A 75 mm pulley was fitted to input shaft of the gearbox. The variable frequency motor could alter the speed of the metering mechanism. The speed of the metering disc can be directly noted from the display unit. Hundred plants were fed and the number of plants missed were counted and expressed as %.

The machine travel speed at the recorded rpm is given by the formula as below.

$$S = \frac{\pi D N}{1000} \times 60 \quad (2)$$

where S = machine travel speed, km/h, D = diameter of the ground wheel, m, N = revolutions of ground wheel per minute.

For measuring the forward speed in the field, the time taken by the tractor at a particular gear and engine rpm to cover a distance of 50 m length was noted and speed was calculated. This process was repeated for other gear ranges and engine rpm till the desired speed was obtained. Adjusting the hand throttle lever could vary the tractor engine rpm.

Field Performance Evaluation

The two row tractor drawn mechanical model of sugarcane settlings grown in protrays was field evaluated for planting of Co 99004 variety in comparison with manual planting of sugarcane settlings (Figs. 6, 7).

A field of 75 × 50 m size was prepared for the evaluation. The seedbed was prepared by two ploughings, followed by rototilling to make fine tilth and broadcasting of recommended dose of urea and super phosphate. Sugarcane settlings were removed from the protays grown in the glass house. The height of the settlings at the time of planting was about 15 cm kept under shade near the planting field. Soil parameters such as moisture content, bulk density and cone index were also recorded.

Fig. 6 Field operation of two row tractor drawn mechanical planter for sugarcane bud chip settlings raised in protray (side view)

Fig. 7 Field operation of two row tractor drawn mechanical planter for sugarcane bud chip settlings raised in protray (back view) with planted settlings

Operation of the Planter

The settlings were carefully removed from the protrays and placed on the sugarcane bud chip settling tray. Tractor of 35 hp power was operated at about 1.4 km/h choosing the best tractor gear. Two persons seated on the rear of the equipment constantly dropped the sugarcane settlings through the holes of the rotating metering device. While falling through the chute, due to the combination effect of soil at the root base and parachuting effect of leaves, the root portion is always at the bottom and tip of the settlings is on the top. During the movement of the tractor in the forward direction, shoe type soil opener, opens up the soil. Sugarcane settlings which is dropped by the person, falls into this opened soil. After a small time lag, the soil closure wheel which is placed at an angle of 15° provides the side support to the settlings, thereby avoiding it to fall down.

The intrarow spacing can be adjusted from 0.45 to 1.2 m based on the requirement and the plant to plant distance by the gear ratio between the power transmission mechanism and the ground wheel. Since there is likely to be some slip in the motion of the tractor in its forward motion and also in the ground wheel in contact with the soil, the plant to plant distance cannot be maintained accurately. While the tractor is moving in the forward direction, the furrow opener opens up the irrigation channel on both sides of the sugarcane settlings planted (Fig. 8). The plant missing, plant mortality after 20 days, depth of planting, planting angle, plants in lying down position were recorded.

Fig. 8 View of field after one day of planting using two row tractor drawn mechanical planter for sugarcane bud chip settlings raised in protray

Plant Missing

Plant missing was observed in the field. In the field experiments, missing hills were noted out of 100 sugarcane bud chip settling planted. The percentage missing seedling was calculated using the data.

Plant Mortality After Twenty Days

The mortality was recorded after 20 days of planting and expressed in percentage.

$$PM = \left(1 - \frac{PS}{PT}\right) \times 100 \quad (3)$$

where PM = mortality, %, PS = number of plants survived after 20 days of planting, PT = total number of plants planted.

Required Feed Rate

The rate at which plants can be fed into the planter was calculated by using the following formula (Srivastava et al. 1994).

$$R_{fr} = \frac{6000 v_m \lambda_r}{d_p \times n} \quad (4)$$

where R_{fr} = required feed rate of seedling per minute, V_m = forward speed of planter, m/s, λ_r = number of rows, nos, d_p = actual seedling spacing along the row, cm, n = reduction ratio from ground wheel to discs.

Planting Density

The number of plants per hectare was calculated according to following formula (Kavitha 2005).

$$R_d = \frac{10^8}{d_p R_s} \quad (5)$$

where R_d = planting density per hectare, R_s = actual row spacing, cm, d_p = actual seedling spacing along the row, cm.

Machine Parameters

Machine parameters like forward speed, wheel slip, field efficiency, machine capacity and fuel consumption were measured and recorded according to the recommendations of the Regional Network for Agricultural Machinery (RNAM) test codes and procedures for farm machinery (Stevens 1982; Anonymous 1983).

Sugarcane Juice Quality Analysis

Ten cane samples were collected at random. The canes were de-trashed and the tops were removed at a point where it breaks when a gentle pressure was applied at the top node. The juice was extracted using a clean three roller power operated crusher with a minimum of 65 % of juice extraction within 12 h of harvest. The basic parameters of sugarcane juice viz., (i) Brix by using hand held refractometer, (ii) Sucrose or pol by Saccharimeter (iii) Purity and (iv) Commercial cane sugar % were determined following the procedures of Chen and Chou (1993).

Statistical Analysis

The data were analysed as factorial design. Statistical significance was determined at $P < 0.05$ for ANOVA and the means were separated using least square difference.

Cost Economics Sugarcane of Mechanical Planter for Sugarcane Bud Chip Settlings

The total cost of mechanical planter for sugarcane bud chips was calculated. The fixed and variable costs for operating the machine per hour were calculated as per the procedure enumerated by Regional Network for Agricultural machinery (Anonymous 1983). The performance was compared with manual planting in terms of savings in cost and time. The break-even point and pay back period of the equipment were also worked out.

Results and Discussion

The specifications of the two row tractor drawn mechanical planter for sugarcane bud chip settlings raised in portray developed in the research workshop of Central Institute of

Table 1 Specifications of experimental model two row mechanical planter for settlings raised from sugarcane bud chips

	Particulars	Details
1	General	
	Type	Tractor drawn
	No. of rows	Two
	Power source	35 hp tractor
2	Overall dimension (L × B × H, mm)	1,800 × 1,600 × 1,400
3	Total weight of the implement	400 kg
4	Planting mechanism	
	Type of planting mechanism	Rotary disc type
	Ground wheel to gear box	Chain and sprocket
	Gear box to discs	Belt and pulley
	Number of disc	2
	Diameter of disc, mm	460
	Diameter of hole on top disc (mm)	70
	Diameter of the hole on bottom disc (mm)	85
5	Type of Soil opening shoe	Shoe type of 100–120 mm wide with depth adjustment
6	Soil covering device	Press wheel inclined at an angle of 15° with the vertical
7	Furrow opener	Pair of wings at spacing of 200 mm at the front and 580 mm towards the wings
8	Plant geometry	
	Row spacing (mm)	Adjustable (900–1200 mm)
	Plant spacing	Adjustable by changing sprockets/pulley or feeding in alternate holes
	Missing (%)	3–4
9	Suitability	
	Type of settlings	Settlings with soil block
	Crops	Sugarcane settling
		Possibility of adopting for other crops
10	Power transmission system	
	Diameter of the ground wheel (mm)	75
	No. of teeth of the sprocket on ground wheel shaft	18
	No. of teeth in the bevel and pinion	18
	Diameter of the output pulley (mm)	100
	Diameter of the metering pulley (mm)	150
	Size of the belt from the gear to the disc	B 42 'V' belt
	Size of the belt from Disc to disc	B 42 'V' belt

Agricultural Engineering, Regional Centre Coimbatore are given in Table 1.

Optimization of Speed of Operation on Plant Missing

Different parameters affect the performance of mechanical planters, one of which is machine forward speed. Machine travel speed is known to increase the operator feeding rate resulting in higher skips in feeding or missing (Suggs 1979; Way and Wrigh 1987; Ladeinde et al. 1995; Juric et al. 1997; Kavitha 2005). Performance evaluation of mechanical planters have indicated that missing varied from 1 to 9.6 % for speed of operation varying from 0.5 to 1.2 km/h (Dooley 1983; Tsuga 1999; Ladeinde et al. 1995; Chaudhuri et al. 2002; Satpathy 2003; Kavitha 2005). The interaction effect studied between machine speed and % plant missing using the developed Sugarcane bud chip settlings planter is given in Table 2.

Table 2 Effect of speed of operation on missing sugarcane settlings in rotating type metering mechanism

Speed of operation (km/h)	Missing of settlings (%)
0.6	0^{a}
0.8	0^{a}
1.0	0^{a}
1.2	0.33^{a}
1.4	2.67^{a}
1.6	7.33^{b}
1.8	10.33^{c}
Cv	23.15
CD (0.01)	2.87
SEM	0.81

^{a,b,c} as superscript denote values with similar superscript in the column did not differ significantly at 5 % level

From the Table 2, it is seen that till 1.2 km/h the missing was almost nil. At 1.4 km/h, the missing was 2.67 %. At higher of speeds (1.6 and 1.8 km/h), the missing was found to be in the range of 7.33 and 10.33 % respectively.

The performance evaluation of tractor drawn two row mechanical planter for sugarcane bud chips settlings is given in Table 3. The field capacity of the mechanical planter was 0.15 ha/h at 75 % field efficiency.

Table 3 Performance of two row tractor drawn mechanical planter for sugarcane bud chip settlings

Particulars	Details
Soil conditions	
Moisture condition, % (d.b.)	12–13
Bulk density (g/cc)	1.35
Machine performance	
Width of operation (m)	1.35
Row to row spacing (m) (adjustable) (m)	0.45–1.2
Plant to plant spacing (m) (adjustable)	0.45
Optimum speed of operation (km/h)	1.4
Required feed rate, settlings/min/row	28–30
Planting density, settlings/hectare	Depends on selected spacing
Slip at 12 % moisture content (d.b)	3–4 %
Field capacity	0.15 ha/h

Table 4 Biometric observations of sugarcane bud chip settlings planted by mechanical planter in comparison to manually planted sugarcane bud chip settlings

Particulars	240 days	300 days	Harvest
Diameter at middle (cm)	2.67 ± 0.21^{a}	3.00 ± 0.23^{b}	3.2 ± 0.19^{c}
	$(2.65 \pm 0.29)^{*a}$	$(2.98 \pm 0.13)^{*b}$	$(3.11 \pm 0.16)^{*c}$
	Statistically on par at 5 %		
Height (cm)	200 ± 8.12^{d}	228 ± 7.52^{e}	239 ± 6.92^{f}
	$(198 \pm 6.16)^{*d}$	$(226 \pm 5.87)^{*e}$	$(236 \pm 4.98)^{*f}$
	Statistically on par at 5 %		
Single cane weight (kg)	1.13 ± 0.26^{g}	1.36 ± 0.21^{h}	1.4 ± 0.19^{i}
	$(1.09 \pm 0.25)^{*g}$	$(1.29 \pm 0.19)^{*h}$	$(1.35 \pm 0.19)^{*i}$
	Statistically on par at 5 %		
Juice (%)	55.32 ± 0.81^{j}	57.65 ± 0.76^{k}	60.65 ± 0.98^{l}
	$(54.82 \pm 0.76)^{*j}$	$(56.52 \pm 0.61)^{*k}$	$(59.39 \pm 0.66)^{*l}$
	Statistically on par at 5 %		
Yield (t/ha)	N.A	N.A	131.24 ± 8.26^{m}
			$(130.39 \pm 5.68)^{*m}$

^{a,b,c,d,e} denotes values of different superscript in row are significantly different at 5 % level. Values of same superscript in column are on par at 5 % level

* Values in parenthesis is for manual planting of bud chips

Biometric Observations

The biometric observations in terms diameter of the cane in the middle, height of the cane, single cane weight, juice % and yield were recorded on the 240th, 300th day and at the time of harvest and details are given in Table 4. It is seen from the table, that the diameter in the middle of the cane which is planted by mechanical planter increased from 2.67 ± 0.21 to 3.2 ± 0.19 cm. The corresponding values by manual planted sugarcane settling were 2.65 ± 0.29 and 3.11 ± 0.16 cm, respectively, which was on par at 5 % level. Similarly it was observed that the height of the mechanically planted sugarcane plant was 200 ± 8.12, 228 ± 7.52 and 239 ± 6.92 cm on the 240th day, 300th day and at the time of harvest, respectively. The corresponding values of the manually planted sugarcane settlings were 198 ± 6.16, 226 ± 5.87 and 236 ± 4.98 respectively, which were on par with mechanically planted settlings. Single sugarcane weight at the time of harvest for the mechanically planted settling was 1.4 ± 0.19 kg which was on par with manually planted bud chip settlings with 1.35 ± 0.19 kg. The juice content and the yield of mechanically planted sugarcane settlings was 60.65 ± 0.98 % and 131.24 ± 8.26 t/ha at the time of harvest, whereas the manually planted sugarcane settlings recorded the juice content of 59.39 ± 0.66 % and yield of 130.39 ± 5.68 t/ha, which was on par with mechanical planting. This indicates that the biometric parameters of the

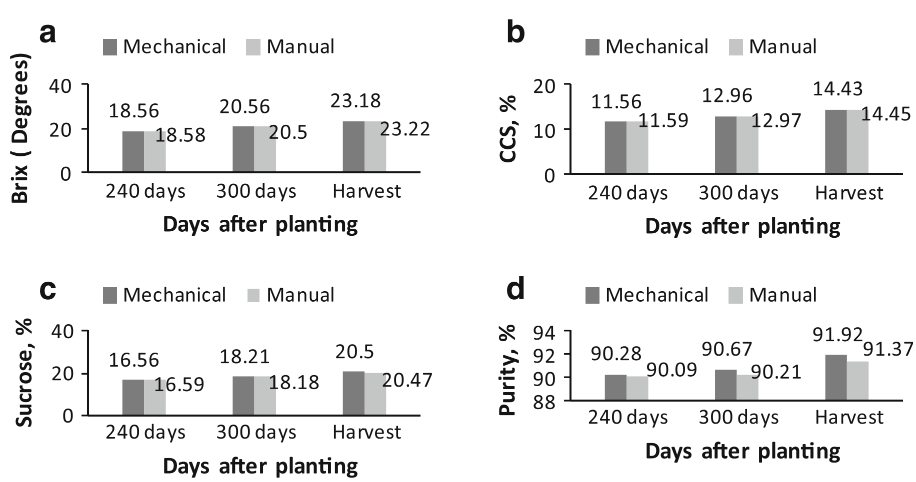

Fig. 9 Juice quality parameters of harvested canes planted using the mechanical planter in comparison with the manually planted sugarcane settlings. **a** Brix (°) of mechanically versus manually planted sugarcane bud chip settlings. **b** CCS of mechanically versus manually planted sugarcane bud chip settlings. **c** Sucrose (%) of mechanically versus manually planted sugarcane bud chip settlings. **d** Purity (%) of mechanically versus manually planted sugarcane bud chip settlings

mechanically planted sugarcane buds chips settlings was on par with that of manually planted sugarcane bud chip settlings.

Juice Quality

The quality parameters of the juice extracted from harvested sugarcane which were planted using the mechanical planter in comparison with to manually planted sugarcane settlings is depicted in terms of brix (Fig. 9a), Commercial cane sugar (Fig. 9b), sucrose % (Fig. 9c) and purity (Fig. 9d). From the Fig. 9, it is seen brix content increased from 18.56° to 23.18 % at 240 days of planting to the time of harvest for mechanically planted settlings. The corresponding values of manually planted bud chip settling were 18.58°–23.22°. The commercial cane sugar, sucrose and purity of mechanically planted sugarcane settling was 14.43, 20.50 and 91.92 %, respectively which was on par with manually planted sugarcane settlings with corresponding values of 14.45, 20.47 and 91.37 %, respectively. This clearly indicates that the quality of juice from canes of the mechanically planted sugarcane bud chip planter was on par with that of manually planted sugarcane bud chip settlings.

Cost Economics Sugarcane of Mechanical Planter for Sugarcane Bud Chip Settlings

The cost of the two row tractor operated sugarcane bud chip planter worked out to Rs. 60,000. The cost economics analysis revealed that the cost of planting/hectare was Rs. 5,410 with the tractor mounted two row sugarcane bud chip planter while it was Rs. 8,950 with manual bud chip planting at wage rate of Rs. 200, Rs. 150 and Rs. 120/day for tractor operator, men and women labour, respectively. The saving in cost and labour was 40 and 85 %, respectively by mechanical planting over manual bud chip planting. The breakeven point and the payback period was 336 ha and 2.50 year, respectively for two row tractor operated sugarcane bud chip settling planter.

Conclusions

The tractor drawn two row mechanical planter for the sugarcane settlings grown in protrays had a field capacity of 15 ha/h at optimized speed of operation of 1.4 km/h. The biometric parameters of the settlings and the sugarcane juice analysis of the cane from mechanically planted sugarcane bud chip settling plant were on par with cane from manual planting. The cost analysis of the equipment revealed a significant savings in costs and time thus could be adopted as an effective mechanization tool for planting of sugarcane bud chip settlings. The planter could be used as an effective planting tool in Sustainable Sugarcane Initiative programme for sugarcane.

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