

Design Refinement of 2 Row Tractor Mounted Sugarcane Cutter Planter

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ABSTRACT

Sugarcane planting is a very labour intensive job and involves considerable human drudgery. Cost of sugarcane planting by mechanized method is less compared to traditional methods. It also reduces drudgery involved in unit operations of sugarcane planting. Thus, recently developed sugarcane cutter planters are getting very good acceptance amongst sugarcane growers. Generally planting of any crop is very much important as far as the crop growth and yield is concern. This paper describes regarding the design refinement of a sugarcane cutter planter and its prototype development. In this machine, the complete sugarcane, which is fed by the laborers sitting on the machine, is cut automatically into pieces before dropping into furrows. It also opens the furrows, applies fertilizer, chemical and fungicide and also covers the sets and presses it automatically. It is operated by 35 hp tractor and has 2 units. The performance of the planter was evaluated in field. Its field capacity was 0.2 ha/hr with field efficiency of 80.0 percent at effective working width of 1.35m and forward speed of 1.85 km/hr at 2nd low gear. The set length was 31.8 cm with an average overlap of 6.48 cm observed at the speed of 2.5 km/hr. The seed rate capacity of machine was found 5.55 tones per ha.

Key words: Sugarcane, cutter, planter, tractor operated, India

1. INTRODUCTION

Sugarcane, an important agro-industrial crop in India, plays a pivotal role in national economy by contributing 1.9 per cent to GDP. The crop is cultivated in 4.22 m ha producing 300 mt with a productivity of 75-80 t/ha. However, there have been fluctuations in area as well as productivity over the years on account of several factors. Generally gur (Jaggery) and sugar are prepared from sugarcane. Sugarcane is propagated from cuttings, rather than from seeds. Although certain types still produce seeds, modern methods of stem cuttings have become the most common method of reproduction. Each cutting must contain at least one bud, and the cuttings are usually planted by hand. There are various methods of sugarcane planting like flat, trench, pit, staggered row and spaced transplanting. Hand harvesting accounts for more than half of the world's production, and is especially dominant in the developing world. Sugarcane planting requires about 350 man-hours and 30-40 bullock pairs per hour per hectare.

Mechanization of sugarcane harvesting is an essential input to the modern agriculture, as it enhances better productivity, besides reducing human drudgery and cost of cultivation. Cost of sugarcane harvesting by mechanized process is almost one third of complete manual process. Thus sugarcane planter cutters are getting great response from farmers, due to the reduction of drudgery involvement in unit operations, i.e. sett preparation, carrying of seed

cane, opening of furrows, dropping of setts, pesticide application, fertilizer placement, and covering and pressing setts.

But the majority of small scale industries in India, presently engaged in manufacture of agricultural implements are lacking design capability, for manufacturing its components, proper selection of materials and metallurgical treatments, proper tolerances for components and assembly methods to ensure quality durability and reliability. Moreover, these industries do not have R & D facilities and qualified manpower to produce quality products. Considering above points in mind, development of a 2-row Tractor Mounted Sugarcane Cutter Planter was undertaken based on the needs of farmers. The major sugarcane growing areas are Maharashtra, U.P. and other few developed states of India. The planters manufactured in India are trailing type and PTO driven. Based on the survey conducted, it was decided to study the PTO driven machines and make design refinement for quality manufacture of these machines.

The tooling should be easily interchangeable to solve the problems of replacement of parts during breakdown. If tooling is standardized manufacture of components will be at reduced cost. During entire design refinement process following points were considered in detail:

- Uniform setts cutting and placement in the furrow.
- Proper chemical treatment of sets.
- Manufacture of standardized components to ensure interchangeability of components.
- Desirable covering of the billets with soil (either with shovels / leveler).

2. DIFFERENT SUGARCANE CUTTER PLANTER

The latest development in the area of sugarcane planting is the introduction of sugarcane Cutter Planters. In this machine, the operator feeds whole sugarcane manually and cutting of setts is carried out by rotating knives. The other operation of fertilizer application is also carried out. In sugarcane cutter planter the sett cutting is carried out in planter itself and thus no separate machine is needed for sett cutting. The field capacity of the planter is reported as 0.2-0.25ha/h.

At some places, cutter planters are acceptable with various attachments for planting, placement of fertilizer, chemicals, covering and pressing. However, at some places, some of the optional components are not required along with the planter, where the problem of insects/pests infestation does not exist. In such cases, it is not necessary that the unit should be purchased along with all optional components. However, for commercialization of this equipment, it is required to evaluate it on large scale with all the attachments.

A three-row tractor rear-mounted sugarcane planter, which can plant 53,000 to 87,000 setts of cane per hectare, was developed. It saves approx. 80 man-hours per hectare, compared to manual planting. In this type of equipment, best planting is achieved when operated in the 1st gear or in 2nd gear at an engine speed of 1200 to 1400 rev/min (Qaisrani 1992).

The optimum working speed of FMI and AMRI sugarcane planters is 1.2 and 2.65 km/hr respectively. Average effective capacities are found to be 1.04 and 1.68 ha/day respectively. Corresponding average field efficiencies are 64.5 and 34.8 respectively (Singh et al. 2004).

Due to inclusion of sett cutting unit, energy and cost requirements were about 40 per cent less compared with traditional method of planting sugarcane. It is also reported that bud emergence is quicker when the setts are planted with the cutter planter. It also significantly increases the yield per unit area (Srivastava 1978).

Inclusion of furrow guider and ground wheel helped in alignment of setts in the furrow, before pushing the loose soil to cover. It yielded a saving of about 32 per cent in total cost as well as total energy required for raising sugarcane crop (Srivastava 1978).

Sugarcane cutter planter has an effective field capacity of 0.15 hectare per hour. There was substantial reduction of labour requirement from 130-150 man-hours per hectare (by conventional method) to 35-40 man-hours per hectare by machine planting (Bahl et al. 2001).

Yadav et al. (2001) reported that overall requirement of labour for sugarcane cultivation is 33000 man-hours. Labour requirement for preparatory tillage, planting, irrigation, inter-cultural and other operations, harvesting and stripping are 331.5, 238.0, 337.5, 392.0, 816.0 and 11923.0 respectively. He emphasized on the need to develop and popularize sugarcane machinery system based on regional situation.

3. SYSTEM DESIGN

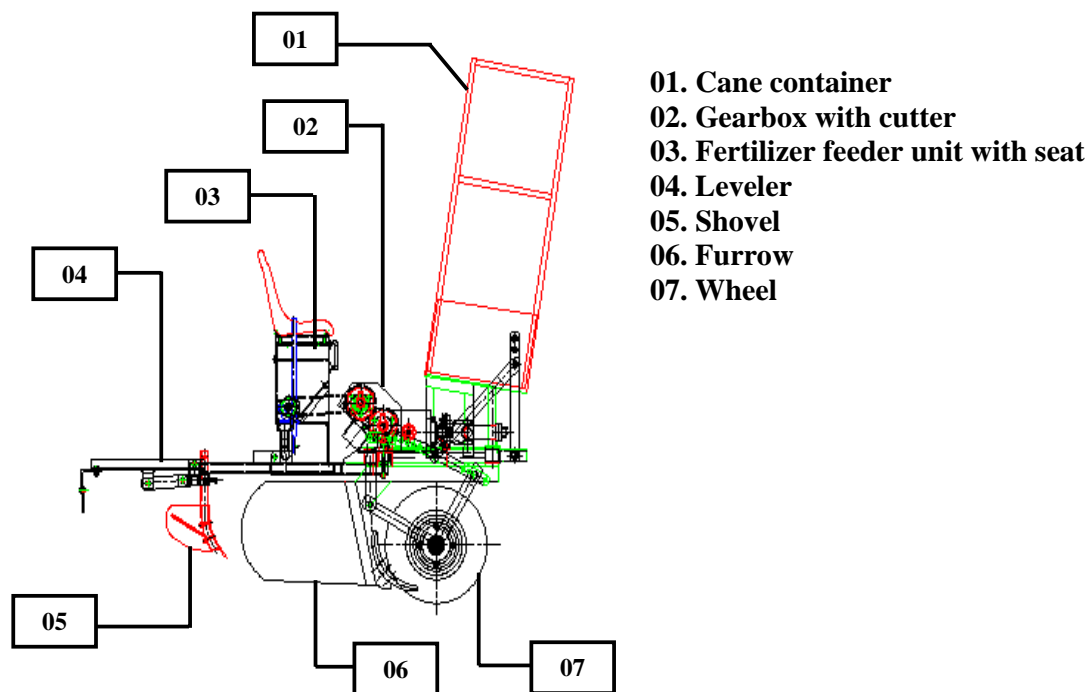


Fig. 1. General Assembly of Sugarcane Cutter Planter

The system was designed with the following specification: -

- Furrow depth : 250-350 mm
- Distance between rows : 675 /775 /875 mm OR 725 / 825 / 925 mm
Adjustable range : 675 to 875
- Length of cut of cane : Avg. 250-300 mm
- Drive to machine : From PTO through gear box, chain & belt
- Weight of the machine : Approx. 400 kg
- Field capacity : 5 to 6 acre per day
- Prime mover : PTO of a 35 to 50 hp tractor

3.1 Salient Features of Designed Sugarcane Cutter Planter

1. Tractor mounted controlled by three-point linkage system
2. Places fertilizer in the row as desired.
3. Makes two rows with facility to change over from 60 cm to-67.5cm or75 cm.
4. Cuts the seed cane automatically.
5. At the cutting point, seed is treated with insecticide (seed treatment)
6. Places seed in the rows automatically with end-to-end jointing & regularly or as desired.
7. Sprays pesticide on the seed in the furrows with pressures (soil treatment)
8. Covers the seed automatically.
9. Close the rows at the same time.
10. Rows are leveled with the leveler by itself.
11. There is minimum damage to the buds.

The manufacturing drawings of all the units of 2-row Tractor mounted Sugarcane Cutter Planter like General Assembly, Main Frame Major Assembly, Furrow Opener Major Assembly, Wheel Major Assembly, Fertilizer Feeder Unit Major Assembly, Ground Leveler Major Assembly, Gearbox Major Assembly, Pesticide Spray Unit Major Assembly, Cane Container Assembly, were prepared taking into consideration the design modification and design refinements wherever necessary to make the machine more reliable.

A high strength, rust proof, lightweight weld able steel fabricated frame was used to support the machine. A compact bevel gear box has been designed which is connected to the PTO of the tractor for driving the various sub systems of the planter.



Fig.2. Sugarcane Cutter Planter Assembly

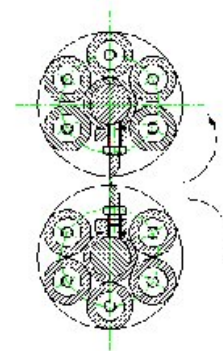


Fig.3. Cutter Bar

4. LABORATORY TESTING

Testing work related to calibration, bud damage determination, quality of cut, length of sett and fertilizer drop was carried out as per the following procedure.

4.1 Calibration

Calibration was done by attaching the planter with tractor by three-point linkage system and powered by PTO. Tractor was operated in second low gear at 1600 engine rpm. Total number of setts cut per minute were collected and counted. This procedure was repeated for three times and average was calculated. Accordingly seed rate required per hectare was calculated.

4.2 Bud Damage Determination

100 setts were selected randomly and number of buds damaged were observed and recorded. Three replications were made and average was calculated.

4.3 Quality of Cut

100 setts were selected at random and nature of cut was observed and noted for three times and average was calculated.

4.4 Length of Setts

100 setts were selected and length of each sett was measured and average was taken.

4.5 Fertilizer Drop

Fertilizer (DAP) box was filled to 3/4th of its capacity. Tractor was operated in second low gear for 60 seconds. Fertilizer dropped during this time was collected and weighed in the physical balance. Fertilizer required per hectare was calculated.

5. FIELD TEST

5.1 Depth of Placement

Planter was operated in the field without levelers. Depth of placement of setts in the furrows was evaluated. Depth was measured at five different places and average was calculated. Depth of placement of setts was controlled by the hydraulic system of the tractor.

5.2 Overlap/ Gap

Planter was run in the field for 60 meters length. All setts dropped were collected and number of setts and length of each sett was measured. The machine was operated in the speed range of 1.74 to 6.03 km/hr at different gear ratios.

$$\text{Average overlap} = \frac{\text{Total length of setts} - \text{Distance (60 m.)}}{\text{Total no. of setts}}$$

$$\text{Average Gap} = \frac{\text{Distance (30 m.)} - \text{Total length of setts}}{\text{Total no of setts}}$$

5.3 Speed of Operation

Planter was run a fixed distance of 90 meter in the field and time required to cover this distance was noted. Simultaneously time required for turning the planter was also noted. As such five observations were taken to get the accuracy.

5.4 Theoretical Field capacity (TFC)

Speed of operation and theoretical width of the planter was noted down for following:

$$\text{Theoretical Field capacity} = \frac{\text{Theoretical Width (m)} \times \text{Speed of operation (km/hr)}}{10}$$

5.5 Actual Field Capacity (AFC)

The plot of 0.2 hectare was selected and time taken to cover this area was noted. Time taken for turning, hopper filling and other operational obstructions was also noted

5.6 Field Efficiency

$$\text{Field efficiency} = \frac{\text{AFC}}{\text{TFC}} \times 100$$

6. TEST RESULTS

After the fabrication, the prototype was tested in the Laboratory, to evaluate the performance. The prototype was tested in field also, for the evaluation of laboratory performance. The laboratory performance was conducted by connecting the prototype with the PTO of tractor (Ford 3600) to check proper functioning of all assemblies. All critical parameters of the components such as gear teeth, gear train, gear meshing, cane cutting mechanism & chain sprocket mechanism, fertilizer feeder unit etc. were examined for their appropriate functions as per the design. Cutting mechanism was studied by feeding cane of different diameters. The performance of laboratory Trials was found to be satisfactory and machine was recommended to send for field evaluation.

The field performance trial was conducted and following were the observations: -

Table. 1. Data from field performance trials

Sugarcane variety	Cos-767
Name of tractor used	Zetor 2522
Gear used	2 nd Low
Row to row distance	27"
Previous crop	Follow Sand
Depth of seed placement	17.50 cm.
Area covered	3 Acres
Length of observations	10 m.
No. of setts	39
No. of gaps	11
Gap's length (range)	10 - 35 cm

Gap's length (average)	20 cm
No. of overlapping	12
Overlapping length (range)	5 – 7cm.
Overlapping length (average)	6.48 cm
Length of sett (range)	25 - 37.50 cm
Length of sett (average)	31.80 cm.
No. of buds/setts (range)	3 - 7
No. of buds/setts (average)	3.2
Dia. of setts. (range)	19 - 28 mm.
Dia. of setts (average)	23 mm
Average no. of damaged buds	2
Weight of setts	3.75 kg.
Field capacity	0.20 ha/hr. or 1.60 ha/day
No. of labours employed	5
Seed dropped/ha	5.55 t/ha.
Speed of operation	1.85 km./hr.

6.1 Field Evaluation Photographs



Fig.4. Sugarcane Cutter Planter without Leveler



Fig.5. Sugarcane Cutter Planter with Leveler

7. CONCLUSIONS

The field capacity of the machine was 0.2 ha/hr. or 1.6 ha/day (considering 8 working hrs/day). The field efficiency was 80.0 percent at effective working width of 1.35 m (row to row distance 0.675 m) with a forward speed of 1.85 km/hr(2nd Low gear). A sett length of 31.80 cm and overlap gap 6.48 cm was observed at the engine speed of 1600 rpm at a forward speed 1.85 km/hr. It was found out that this sugarcane cutter planter saves about 70 per cent labour requirement as compared to conventional method. The performance of the planter is also very good. The sugarcane planted with the 2-row Tractor mounted Sugarcane Cutter Planter were free of any damage of buds. Sugarcane growers of India will found this unit acceptable. The cost of operation per ha in case of this equipment will be in the range of Rs.

2000 as compared to Rs. 7000 manually. Thus, this kind of equipment reduces the cost of operation, impart consistency, better utilization of resources, quality work performance resulting in better production and productivity.

8. ACKNOWLEDGEMENT

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