RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 10 | Issue 2 | October, 2017 | 367-373
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/10.2/367-373**

# Performance evaluation of sugar cane cutter planter using different parameters

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**Received :** 28.04.2017; **Revised :** 01.08.2017; **Accepted :** 15.08.2017

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■ **ABSTRACT :** Sugarcane planting is a very labour intensive job and involves considerable human drudgery. Planting creates the foundation for a crop and plays a crucial role in its growth and yield. Study was undertaken to evaluate the performance of two different models of sugarcane planters. One model was Khalsa PE-630 type cuter planter manufactured M/S Punjab engineers, Meerut and the other was ITI make cutter planter designed by Indian Institute of Sugarcane Research, and manufactured by Indian Telephone Industries, Rai Bareli. In addition to this two different experimental test set ups based on different principals were developed for measuring cutting forces for sugarcane cutting. It was observed that field capacity of Khallsa make planter was 0.20 ha/ hr with the field efficiency of 87.50% at effective working width of 1.34 m and a forward speed of 2.54 km / hr at 2nd low gear. A set length of 32.96 cm with average.

■ **KEY WORDS :** Sugarcane, Cutter plauter

■ **HOW TO CITE THIS PAPER :** Kumar, Sumit, Pal, Surendra, Khandai, Suryakanta, Kumar, Manish and Tripathi, Ashok (2017). Performance evaluation of sugar cane cutter planter using different parameters. *Internat. J. Agric. Engg.*, **10**(2) : 367-373, **DOI: 10.15740/HAS/IJAE/10.2/367-373.**

Sugarcane (*Saccharum officinarum* L.) has been known from the earliest times even before the Christian era and ancient civilization. India is a home of thin class of canes. There are historical and botanical evidences to prove it. These types of canes were under cultivation in indo – Gangatic plains. Sugarcane is the important cash crop of India and holds the prominent position as a cash crop. It is main sources of sugar, gaur and khandsari in the country. It is cultivated in an area of about of million – ha with an average production of 75 tonnes/ ha. Total production of sugaracane has been increasing steadily from 230 million tonnes in 2003-04 to 300 million tonnes in 2006-07. Sugar availability in the country has been about 185 lakh tonnes. To meet the requirement of increasing population, sugar production in the country has to be increased.

Basically planting involves opening of the furrow, placement of treated sugarcane setts and fertilizers, its covering and compaction, sugarcane planting ranks second highly labour intensive and time consuming. Sugar cutter planting ranks second highest in terms of labour requirement after harvesting. Sugarcane production requires 3,300 man – hours for different operations. labour operation, labour required for preparatory tillage manuring, planting irrigation, intercutlure and other operations, harvesting and stripping are 3313.5, 238.0, 292.0, 818.0 and 1,192.0 man – hours, respectively, considering the present trends to availability of labour for farms operations, it has been experienced that use of modern machinery is inevitable. Planting or sowing

creates the foundation for a crop and plays a crucial role in its growth and yield. Its importance is felt more for sugarcane as it is cultivated more than once and as it is a yearly crop. Time for planting takes a large share. Late planting of sugarcane has been reported as one of the reason for low yields. The rising labour charges, scarcity and more time required in conventional planting demand for mechanization.

Traditionally sugarcane has always planted manually. It is includes opening of the furrow with a local plough or cultivars at a distance of 75 to 90 cm. After this already prepared mixture of fertilizer NPK is spread uniformly in them. The sets are cut manually and dipped in the chemicals. The sets are then planted in furrows end to end taking care that one three budded sett falls in each running 30 cm length of furrow. After this furrows are covered with 5 to 7 cm of soil and field is leveled by heavy plank. However to reduce the cost of planting, drudgery and proper placement of fertilizer, machinery of sugarcane planting has been developed in India. These machines are basically of two types, widely known as drop planters and cutter planters. In drop planters precut sugarcane sets of desired length are fed in to the machine. The setts may be cut manually or mechanically. The planters consists of two vertical rotating drums with 12 circular vertical seed compartment in each drum. The rotating drum is powered by ground wheel through central shaft. In the cutter planter, whole cane is feed. It is provided with the cutting unit, which cuts the fed cane to a pre- determined length and carries it to the furrow.

Presently most common design of planter is the cutter planter which performs the job of sett cutting, furrow opening, fungicidal and anti-termite treatment of setts, placement of the fertilizer in bands or either side of setts, covering and pressing the setts. Whole cane is fed through the chute manually from the sugarcane through. Designs of two and three row cutter planters are commercially available. There are about 10 to 15 manufacture of sugarcane planters in the country who manufactur different models. These models are tested and evaluated at different research stations in the country. Stills there are some parameter, which needs to be improved. Considering the present trends and problems, this research work is proposed with following objectives.

– To conduct laboratory testing of sugarcane cutter planter.

– Design analysis of different parameters, of sugarcane cutter planter.

## METHODOLOGY

Study was under take to evaluate the performance of two different model of sugarcane cutter planter. One model was Khalsa PE- 630 type cutter planter manufactured by m/s Punjab Engineers, Meerut. Another model was ITI make manufactured by Indian Telephone Industries, Rai Bareli.

**Constructional details of the planter :**

*Main frame :*

Frame of the planter should be rigid and strong as all the parts are mounted on it. Frame of Khalsa make planter was made of hollow squares having thickness 8 mm, length 197 cm and width 184 cm. ridger bodies were attached to it with the help of nuts and bolts so that desired spacing could be achieved. On the frame seed hopper, sett cutting unit and fertilizer box was mounted. At the rear side of the frame covering and compaction unit was attached. In ITI make planter main frame was made of hollow squares having thickness 8 mm length 135 cm and width 163 cm fertilizer boxes, seed hopper and sett cutting unit were mounted on it. At the rear side of the planter covering unit and pressing rollers were attached. Ridger bodies were one of important component of the sugarcane cutter planter, the role of which was to issue the deposition of seed deep in to the soil where optimum condition for germination were available. Type of ridger bodies in Khalsa Make planter was of reversible shovel type. In ITI make planter ridger body was of shoe type. Power transmission was main functional unit of sugarcane cutter planter. Power was delivered through tractor PTO to the machine through telescopic shaft. Power was transmitted to cutting unit fertilizer application, unit agitator and chemical application unit by using gears, chain and sprocket. Set cutting unit was one of the main components of sugarcane cutter planters. In Khalas planter each set – cutting unit has two blades, which were mounted on separate shafts rotating in opposite direction. Five rubber rollers were provided on each shaft, which holds the cane, which is fed manually and blades cuts it in to desired length. The cut pieces were then dropped in the furrows. Spacing between the setts depends upon the forward speed of the tractor. In ITI make planter each set – cutting unit has two blades, which were mounted on a circular plate. In one revolution

of the shaft two sets were cut. In the mechanism cane needs to be hold by the operator. As the first cut is accomplished operator has to push the cane downward for second cut. Fertilizer box was made up of G.I. sheet with suitable cover. Box is provided with bonnet catcher, which helps in easy opening and closing. A common agitator shaft was provided at the center of the box. Two fluted rollers were provided at the bottom of the box. Just below the fluted roller transparent tubes were attached to carry the fertilizer and deliver it in to the furrows. In ITI make sugarcane planter two separate fertilizer boxes were provided. Agitator was absent in these boxes. For control of borers and termites, application of chemicals was done at the time of planting. However once the plant have grown up, it become difficult to enter in to the field. Both the machines have two tanks, one for fungicide application and the other for insecticide application. The chemical were spread on setts through the nozzles. Flow rate of chemical was adjusted by control levers. Covering unit comprises of furrower in the center of two units and a shovel with half mould board plate behind each row for covering the sets with moist soil. In both the machines covering unit is of the same type. Loose soil over the setts needs to be compared and this was accomplished by compaction unit. In Khalsa make planter compaction was done with the help of flat where as in ITI make planters press rollers were used for the same purpose.

It was necessary to calibrate the planters before putting. It is the actual use of desired seed and fertilizer in the field.

*Calibration :*

Calibration was done by mounting the planter on tractor by three point linkage system and the planter was powered by tractor 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. Seed rate required per hectare was calculated. Fertilizer drop was filled to $3/4^{th}$ of its capacity. Tractor was operated in second low gear for 30 second. Fertilizer dropped in the time was collected and weighed in the physical balance. Fertilizer required per hectare was calculated. Test of fertilizer drop was carried for urea, DAP and single super phosphate.

*Field test :*

Before conducting the trails of these planter field conditions *i.e.* soil moisture content, bulk density etc. were observed. Planter was operated in the without covering device. 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. Planter was run in the field in 30 meters length. All setts dropped were collected and number of setts and length of each setts was measured.

*Operation :*

Free socket on the torque transducer and speed pick- off cables were inserted in to appropriate plugs provided on the rear of the indicator. Indicator was connected to the main supply and main switch was depressed. The switch was illuminated. Allowed 10 to 15 minutes for the indicator to reach the temperature equilibrium. With the transducer at rest and not torque applied, adjusted the zero controls for torque and speed to give a display reading of zero $\pm$1s.d. on the corresponding meter. Torque CAL. Switch was depressed and torque SPAN control was so adjusted that the torque meter display the values give on the transducer calibration certificate. Display was adjusted to give the correct value to $\pm$ 1 l.s.d., the same was repeated for the speed.

## ■ RESULTS AND DISCUSSION

Tractors operated sugarcane cutter planter as tested in laboratory as well in the field to study the performance. Before testing, the planter was completed in all respect *i.e.*, transmission system, sett cutting unit and all other moving parts were working well.

**Performance of sett cutting unit :**

*Metering :*

Average number of setts dropped in a 60 seconds was 130 and 126 in Khalsa and ITI make sugar cane cutter planters, respectively. Average weight of single sett was 159 g and 135 g for Khalsa and ITI makes planters, respectively. Seed rate required was 9 t/ha and 8.4 t/ ha for Khalsa and ITI make planters, respectively.

*Bud damage :*

Out of 386, 16 buds were observed as damaged

buds (4.14%) in khalsa make planter where as in ITI make planter out of 335, 12 buds were observed as damaged (3.58%).

*Buds per sett:*

Distribution of buds on the set among the selected sett were as follows for Khalsa planter.

**Table 1 : No. of buds per sett (Khalsa make planters)**

| Sr. No. | Buds per sett | No. of Sett, % |
|---|---|---|
| 1. | 02 | 41 |
| 2. | 03 | 52 |
| 3. | 04 | 05 |
| 4. | 05 | 02 |

Distribution of buds per sett was observed. It was found that under Khalsa planter the three buds per sett recorded highest percentage distribution (52%), whereas lowest was for five buds per sett (Table 1). In ITI make planter percentage distribution was highest (48%) where the two bud per sett was observed, where was lowest was for five buds per sett (Table 2).

**Table 2 : No. of buds per sett (ITI make planters)**

| Sr. No. | Bud per sett | No. of setts % |
|---|---|---|
| 1. | 02 | 48 |
| 2. | 03 | 46 |
| 3. | 04 | 04 |
| 4. | 05 | 02 |

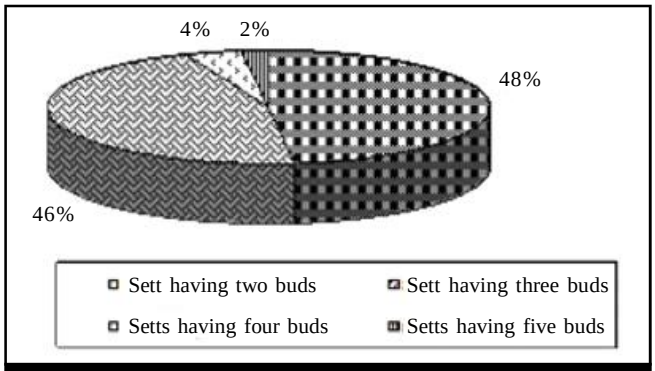


**Fig. 1 : Sugarcane sett cutting pattern in ITI make sugarcane cutter planter**

*Length of sett:*

Average length of setts was observed to be 32.96 cm with standard deviation of 4.33 cm in Khalsa make sugarcane planter whereas in ITI make planters average

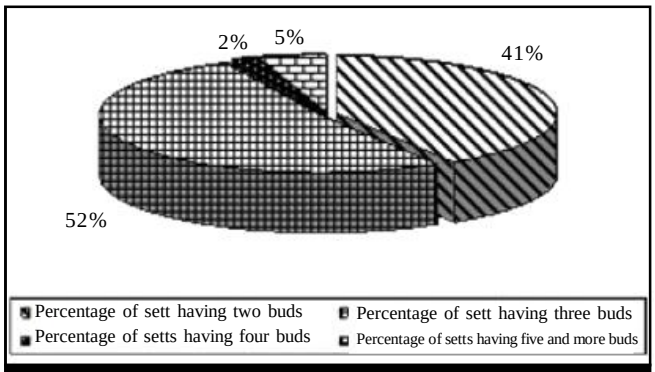


**Fig. 2 : Sugarcane sett cutting pattern in Khalsa make sugarcane cutter planter**

length of setts were 26.90 with standard deviation of 11.33 cm.

**Performance of fertilizer metering unit:**

Tractor was operated in 2nd low gear at 1600 rpm and fertilizer dropped in 30 second was collected for all 15 adjustments of Khalsa make planters and three grove settings of ITI make planter. Fertilizer required per hectare was calculated.

Test for fertilizer drops was carried for different fertilizers *viz.*, urea. DAP and SSP.

Fertilizer distribution per hectare for different fertilizer is given in Table 3 and 4 for Khalsa and ITI make planters, respectively.

**Field performance index:**

*Depth of placement setts:*

The depth of setts placement was controlled by hydraulic system of tractor. Depth of placement of setts in the furrow was found to be 14 cm in Khalsa model and 12.5 cm in ITI make planter. There was quite uniformity of sett placement in the furrows.

**Table 3 : Fertilizer distribution for Khalsa make sugarcane cutter planter**

| Sr. No. | Grove setting | DAP (kg/ha) | Urea (kg/ha) |
|---|---|---|---|
| 1. | 1 | 89.93 | 86.34 |
| 2. | 3 | 193.83 | 237.90 |
| 3. | 5 | 309.93 | 355.78 |
| 4. | 7 | 432.81 | 447.5 |
| 5. | 9 | 575.47 | 618.05 |
| 6. | 11 | 733.42 | 817.26 |
| 7. | 13 | 871.73 | 994.26 |
| 8. | 15 | 1009.67 | 1135.43 |

**Table 4 : Fertilizer distribution for ITI make sugarcane cutter planter**

| Sr. No. | Grove setting | DAP (kg/ha) | Urea (kg/ha) |
|---|---|---|---|
| 1. | 1 | - | 127.00 |
| 2. | 2 | 325.36 | 328.35 |
| 3. | 3 | 487.07 | 467.15 |

**Table 5 : Observed overlap / Gap for ITI make sugarcane cutter planter**

| Sr. No. | Gear ratio | Speed km/ hr | Average overlap 'cm' | Average Gap 'cm' |
|---|---|---|---|---|
| 1. | 1st Low | 1.8 | 3.77 | - |
| 2. | 2nd Low | 2.4 | - | 6.74 |
| 3. | 3rd Low | 3.45 | - | 14.77 |
| 4. | 1st High | 3.05 | - | 9.98 |
| 5. | 2nd High | 4.58 | - | 46.35 |
| 6. | 3rd High | 5.76 | - | 99.66 |

**Table 6 : Observed overlap / Gap in Khalsa make sugarcane cutter planter**

| Sr. No. | Gear ratio | Speed km/ hr | Average overlap 'cm' | Average Gap 'cm' |
|---|---|---|---|---|
| 1. | 1st Low | 1.74 | 9.53 | - |
| 2. | 2nd Low | 1.85 | 8.6 | - |
| 3. | 3rd Low | 3.22 | - | 9.93 |
| 4. | 1st High | 3.05 | - | 5.04 |
| 5. | 2nd High | 4.01 | - | 46.18 |
| 6. | 3rd High | 6.03 | - | 134.17 |

## Actual field capacity :

A plot having length 60 m and width 20 m was selected. Time taken for observation was 36 and 34 minutes including time taken for turning hopper filling and other operation obstructions for Khalsa and ITI Sugarcane cutter planters, respectively. The actual field capacity was found to be 0.20 and 0.21 ha/ hr for Khalsa and ITI make planters, respectively. One filling of cane and fertilizer was required 0.12 ha whereas 10 to 12 filling for seed and 2 to 3 filling for fertilizer required per hectare. The speed of operation was calculated on the basis of time required to cover 90 m distance. The speed of operation was recorded as 1.85 and 1.80 km/ hr, respectively for Khalsa and ITI make sugarcane cutter planters.

## Theoretical field capacity :

Theoretical field capacities of both the planters were calculated as follows:

$$\text{Theoretical field capacity (Khalsa SCP)} = \frac{0.67 \times 2 \times 1.85}{10} = 0.24 \text{ ha/hr}$$

$$\text{Theoretical field capacity (ITI SCP)} = \frac{0.75 \times 2 \times 1.74}{10} = 0.26 \text{ ha/hr}$$

The theoretical field capacities of both the planters were ever to each other.

Field efficacy was calculated by following formula.

$$\text{Field efficiency} = \frac{\text{Actual field capacity}}{\text{Theoretical field capaciety}} \times 100$$

$$\text{Field efficiency of (Khalsa S. C. P.)} = \frac{0.21}{0.24} \times 100 = 87.50$$

$$\text{Field efficiency (ITI S. C. P.)} = \frac{0.20}{0.26} \times 100 = 79.62$$

The field efficiency of Khalsa make sugarcane cutter planter was calculated as 87.50 per cent whereas this was 76.92 per cent for ITI make sugarcane cutter planer.

## Effectiveness of covering and compaction unit :

During the operation of both the planters.

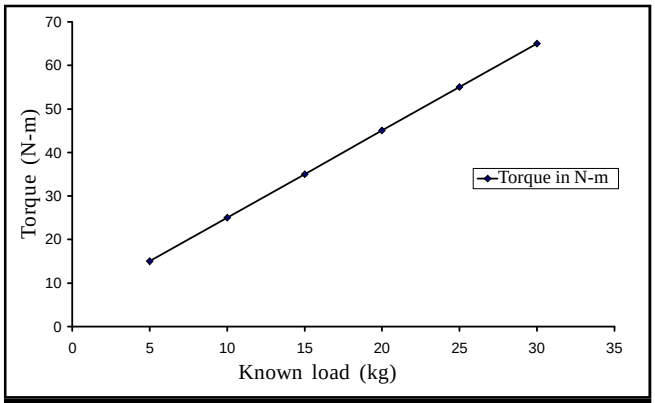


**Fig. 3 : Calibration chart for torque transducer**

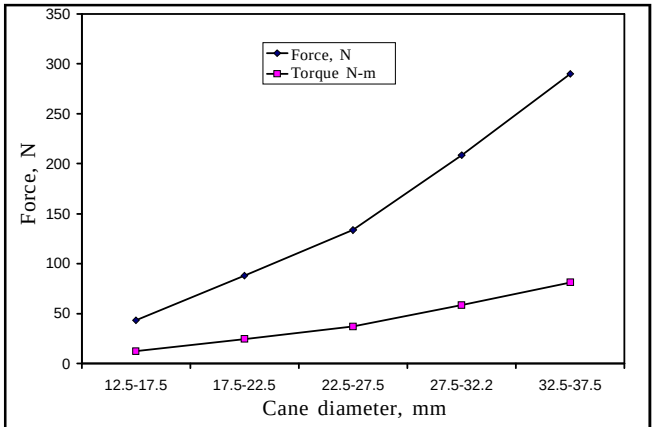


**Fig. 4 : Torque and force requirement for sugarcane cutting (vertical type rotary mechanism)**

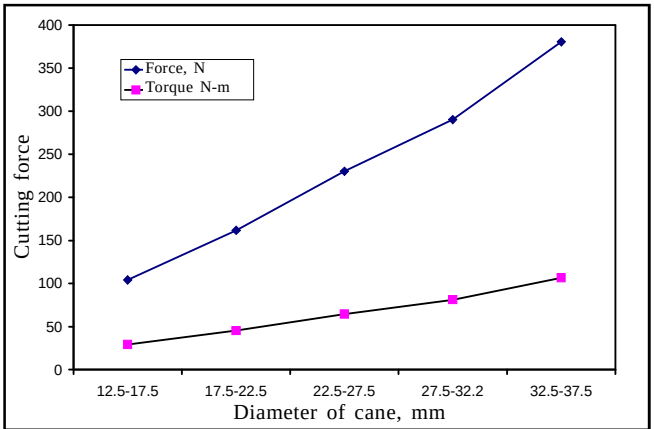


**Fig. 5 : Torque and force requirement for sugarcane cutting (cylindrical type cutting mechanism)**

Uncovered setts were not observed. Compaction of the soil was also found satisfactory.

**Development of experiment test set up:**

*Experiment test set up (Cylindrical cutting mechanism) :*

Minimum cutting force, required to cut the stalk having diameter in the range of 12.5 to 17.5 mm. was observed 104.08 N. Maximum cutting force *i.e.* 380.61 N was required to cut for sugarcane having diameter in the range 32.5 to 37.5mm. Cutting force and torque requirement for different sizes of sugarcane has been listed in Table 7.

**Table 7 : Force required for sugarcane cutting by cylindrical type cutting mechanism**

| Sr. No. | Diameter of the cane 'mm' | Average torque 'Nm' | Force 'N' |
|---|---|---|---|
| 1. | 12.5-17.5 | 29.14 | 104.08 |
| 2. | 17.5-22.5 | 45.28 | 181.78 |
| 3. | 22.5-27.5 | 64.43 | 230.10 |
| 4. | 27.5-32.5 | 81.00 | 290.20 |
| 5. | 32.5-37.5 | 106.57 | 380.61 |

**Experimental test set up (vertical rotary cutting mechanism):**

Minimum cutting force as required to cut a stalk having diameter of 12.50 to 17.5 observed cutting force for this size of sugarcane was 43.51 N. maximum cutting force was required for cutting sugarcane having diameter in the range 32.5 to 37.5 mm. It was observed to be 281.86 N (Table 8).

Cutting force and torque required to cut the sugarcane of different size has been listed in table.

**Table 8 : Force required for cutting sugarcane by vertical type cutting mechanism**

| Sr. No. | Diameter of the cane 'mm' | Average torque 'Nm' | Force 'N' |
|---|---|---|---|
| 1. | 12.5-17.5 | 12.20 | 43.51 |
| 2. | 17.5-22.5 | 24.60 | 87.86 |
| 3. | 22.5-27.5 | 37.04 | 133.57 |
| 4. | 27.5-32.5 | 58.40 | 208.5 |
| 5. | 32.5-37.5 | 81.20 | 290.00 |

**Summary and conclusion :**

With the fast development of the farm mechanization, sugarcane cutter planter were developed in our country. As the sugarcane cutter planters were not the universal devices to be accepted as such, it was far imperative to adopt some test for its performance evaluation in laboratory as well as in the field. A systematic testing work as necessary to evaluate their performance for knowing their suitability for acceptance.

**Overall performance of the planter :**

Khalsa make PE – 630 and ITI make planters were evaluated through field trials and following resulted were obtained.

The field capacity of the machine was 0.20 ha / hr with the field efficiency of 85.97 per cent at effective working width 1.34 m (row to row spacing of 0.67m) and forward speed of 2.5 km/ hr at 2$^{nd}$ low gear. The field capacity of machine was 0.21 ha / hr wit the field efficiency of 73.96 per cent of effective working width of 1.50 m (row to row spacing of 0.75m) and forward speed of 1.8 km/ hr at 1$^{st}$ low gear.

**Performance of set cutting unit :**

At cutting speed of 1600 rpm (engine), a sett length of 32.96 cm at forward speed 2.5 km/ hr (2$^{nd}$ low gear) with an overlap of 6.14 cm was observed. The seed requirement was observed 9.0 tonnes per hectare at the forward speed of 2.5 km/ hr at 2$^{nd}$ low gear. At cutting speed of 1600 rpm (Engine) at set length of 26.96 cm at forward speed of 1.8 km / hr (1$^{st}$ low gear) an overlap of 3.68 cm was observed. The seed requirement was observed 9.23 tonnes per hectare at the forward speed to 1.8 km / hr at 1$^{st}$ low gear.

**Performance of fertilizer metering mechanism :**

The fertilizer metering mechanism was force feed type width different groove setting with fluted rollers. It worked satisfactory for granular fertilizer such as DAP and urea. Fertilizer drop excess than the recommended. Fertilizer metering mechanism could not meter the powdery fertilizer such as single super phosphate. The fertilizer metering unit was force feed type with three different groove settings. It functioned well for DAP and urea but it could not meter single super phosphate.

**Cutting force:**

Cutting force required to cut the sugarcane ranged between 104.08 to 380.86 N for cylindrical cutting mechanism. Cutting force required to cut a sugarcane having diameter in the range 12.5 to 37.5.

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