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RESEARCH ARTICLE

Development and Evaluation of Power Operated Sugarcane Sett Cutter

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ABSTRACT

India has the second highest area under sugarcane cultivation, next to Brazil. Sugarcane is cultivated 4.7 million ha with the productivity of 72 tonnes/ha. Tamil Nadu ranks first in sugarcane productivity in the country, recording an average of more than 100 tonne/ha. Manual sugarcane sett cutting method is time consuming, expensive, and involves human drudgery. To reduce human drudgery and time involved in the operation, the sugarcane sett cutter has developed with 3.7 kW diesel engine, basic frame, belt clutch assembly, power transmission assembly, serrated discs, bearings, and safety cover. The rotational speed of 1100 rev./min, serrated disc 160 mm diameter and 45° cutting angle were optimized based on the number of setts cut per hour, fissures in setts and germination percentage. The cost of sugarcane sett cutting for planting by the machine comes to Rs. 91/h, including depreciation, interest, fuel, lubricating oil, repairs and maintenance and operators' wages. The machine could cut 5940 setts/h. The operational cost of the machine comes to Rs. 16/1000 setts and Rs. 1200/ha. Then, it observed germination was 92 per cent. The cost of the machine is Rs. 27,000/-.

Keywords: *Sugarcane; Sett cutter; Engine operated*

INTRODUCTION

India has the second highest area under sugarcane cultivation, next to Brazil. Sugarcane is cultivated in an area of 4.7 million ha with productivity of 72 tons/ha. About 0.5 million people in sugar mills and 7.5 million sugarcane farmers are dependents, and a large mass of agricultural labour are involved in sugarcane cultivation and ancillary activities, constituting 7.5 per cent of the rural population (Singh *et al* 2020). The manual method of sugarcane sett cutting is time-consuming, expensive, and involves human drudgery. Since the higher work strain resulted in low productivity, use of human works should be reduced and replaced with the machines (Intranot and Srithongchai, 1993). Labour for cutting sugarcane is becoming a constraint because manual cutting classified as "hard work" (Lyne *et al.,* 2007). Mello and Harris (2001) investigated the cutting ability of serrated edges as compared to straight and curved smooth edges and found that the roughness of the serrated disc surface removes more sugar cells than smooth discs, but there is significantly less damage to the stalk. Liu *et al.,* 2012 reported that serrated blades require less energy and force than flat blades for cutting the sugarcane setts and yield the desired cut quality.

Studies were conducted under the National Agricultural Technology Project on Sugarcane Mechanization of the Indian Council of Agricultural Research indicate that sugarcane growers are slowly adopting modern sugarcane machinery for tillage and planting either on an ownership or custom hire basis. In India, the sugarcane sets are planted in pieces of three or two buds. In the process of sett cutting, the sets are cut manually by hand and semi-mechanized by using sett-cutting machines. The present method of sugarcane sett cutting for sugarcane planting is mostly manual. Ridge (2001) reported that mechanization is more economical compared to manual methods. Hence, it is needed to develop power operated sugarcane sett cutter for reducing the cost of cultivation and human drudgery.

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MATERIAL AND METHODS

Sugarcane sett cutter (Fig.1) has been developed with 3.7 kW diesel engine, basic frame, belt clutch assembly, power transmission assembly, serrated discs, bearings, and safety cover. The design and development details of the sugarcane sett-cutter and the procedure adopted for evaluating the performance of the machine are given below,

Figure 1. Power Operated Sugarcane Sett Cutter

Selection of prime mover

For prime mover selection, commonly grown sugarcane varieties have been considered. The diameter of sugarcanes measured from 26 mm to 36 mm. Mean diameter was found to be 28.5 mm. Mean dynamic shear strength of sugarcane was experimentally determined to be 66.7 k Pa. Force required to cut the sugarcane is the product of dynamic shear strength of sugarcane and mean cross sectional area of sugarcane which was 40.6 N ($66.7 \times 3.14 \times 0.0285^2/4$). The torque computed as 5.08 Nm and the power calculated to be 1.2 kW/disc. Allowing for frictional losses, a commercially available 3.7 kW diesel engine was selected as the prime mover for operating two discs of the sett-cutting machine.

Development details

The sugarcane sett cutter is powered by a 3.7 kW, 1800 rev/min diesel engine. The basic frame structure of the machine is fabricated with 32×32×8 mm size mild steel angle sections. A 16-gauge of mild steel sheet is used on top of the machine to cover the entire structure. A base plate was made of 38×38×12 mm thick mild steel plate to place the engine. A belt clutch assembly is incorporated between the engine output pulley and the follower for easy engine starting without load. The power transmission assembly is made of V-pulleys and a pair of spur gears. B type V-belts used for the transmission of power from the engine to the shafts. The spur gears change the direction of the two rotating shafts so that the two serrated discs rotate in opposite directions. Antifriction bearings are provided to hold the shafts in position. At the end of each shaft, a serrated disc is provided to perform sett-cutting operations. A metal safety cover is provided over each disc for the operator's safety.

Methodology of testing

Tests were conducted at four rotational speeds of the discs, two serrated discs, and two angles of cut with different pitches to find the machine's output for sett cutting. Three replications were made, and the mean output of the machine found in terms of setts cut per hour. A digital tachometer is used to measure the rotational frequency of the engine crankshaft. The number of setts cut by the machine were counted after operating the machine for a known period. A stopwatch was used to measure the time taken. Statistical analysis of the results obtained. The cost of the machine was determined. Cost of operation of the machine calculated as per the specifications of the Bureau of Indian Standards. From the above data, operational cost of the machine for cutting 1000 setts calculated in comparison with manual sett cutting.

RESULTS AND DISCUSSION

The engine operated sugarcane sett cutter was developed with following specifications,

Speed ratio between engine and serrated discs	:	1:1
Serrated disc diameter	:	356 mm, 160 mm
Pitch of serrations	:	4.5 mm, 2.5 mm
Weight of the machine	:	123 kg
Overall dimensions	:	1700×1400×1400 mm

The performance of the developed sugarcane sett cutter was tested (Fig. 2) with four levels of rotational speeds (900, 1000, 1100 and 1200 rev./min), two levels of serrated discs (160 mm and 356 mm diameter), and two levels of cutting angle (0° and 45°). Fissures were observed less in the case of the setts cut by the disc with a lesser pitch of serrations at 45° angle of cut as compared to the setts cut by the disc with a higher pitch of serrations at 0° of cut (Fig. 3). Sett cutting operation found easier at an angle of 45° of cut rather than at 0° of cut. In addition, the cutting operation was smooth at the disc's high speed at around 1100 rev/min.

Figure 2. Operation of Power Operated Sugarcane Sett Cutter

Figure 3 Quality of setts of cut at different angles and pitches

Effect of the peripheral speed of the serrated disc on machine output at different cutting angles illustrated in Fig. 4 & 5. For both disc, the machine output increased from 900, 1000 and 1100 rev/min of the peripheral speed of disc then the machine output started to decrease. The 45˚ cutting angle found to give higher output in both the disc. This might be due to lesser cutting effort in angled cutting rather than straight cutting. The comparative study with two different diameters of serrated discs revealed that cutting of sugarcane setts better in case of smaller diameter disc having lesser pitch of serrations.

From the above discussions, the rotational speed of 1100 rev./min, serrated disc 160 mm diameter and 45˚ cutting angle were optimized based on a number of setts cut per hour, fissures in setts and germination percentage. Quality cut also achieved with 2.5 mm pitch serrations than 4.5 pitch serrations. Seven-month-old sugarcanes stalks were cut by the engine operated sugarcane sett cutter and the setts were planted in actual field conditions. Germination was 92 per cent. Operational cost of the machine comes to Rs. 91/h, Rs. 16 / 1000 sets and Rs. 1200/ha. The total output of the machine was found to be 5940 setts/h. The cost of the machine is Rs. 27,000/-.

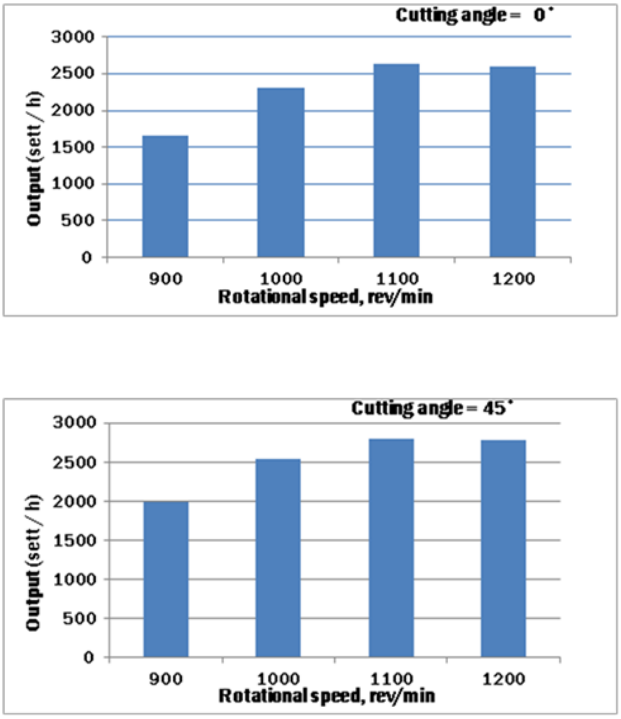

Figure 4. Performance of sett cutter with serrated disc of 356 mm dia at 0˚ and 45˚ cutting angle

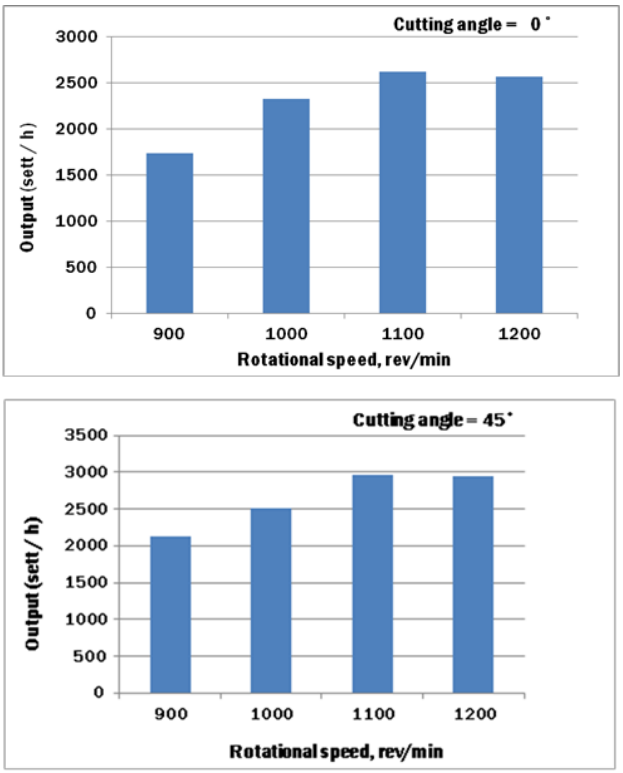

Figure 5. Performance of sett cutter with serrated disc of 160 mm dia at 0˚ and 45˚ cutting angle

Conclusion

The performance of the developed sugarcane sett cutter was tested. Using the machine single, double or three budded sugarcane setts could be cut conveniently. No fissures at 45˚ angle of cut with lesser diameter disc and pitch serration. The output of the machine was 5940 setts/h. Operational cost of the machine comes to Rs. 91/h. Germination was 92 per cent. The cost of the machine is Rs. 27,000/-.

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

We ensure that we have written and submitted only entirely original works, and if we have used the work and/or words of others, that has been appropriately cited.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There was no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS.

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