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Development and Demonstration of a Manually Operated Sugarcane Mother Shoot Cutter

Kamaraj P [a++*] and A.Tajuddin [b#]

[a] Department of Farm Machinery and Power Engineering, Agricultural Engineering College and Research Institute (TNAU), Kumulur- 621 712, Trichy District, Tamil Nadu, India.
[b] Department of Agricultural Engineering, Saveetha Engineering College, Chennai - 622 105, Tamil Nadu, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

India ranks second in the world for sugarcane cultivation after Brazil, with an area of 4.7 million hectares and a productivity of 72 tonnes per hectare. However, traditional sugarcane farming methods require significant inputs such as water, seed, labor, land and fertilizers. Additionally, conventional tools like secateurs, knives, and sickles used for removing the mother shoot are inefficient and unsafe, leading to increased physical strain, a higher risk of hand and eye injuries and excessive drudgery for agricultural laborers. This study aimed to develop a more efficient and

[++] Associate Professor (Farm Machinery);
[#] Professor (Retired) TNAU, Coimbatore- 641 003 and Professor and Head;
**Corresponding author: E-mail: kallaikamaraj@tnau.ac.in;*

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safer tool for removing the mother shoot in sugarcane cultivation, in line with the Sustainable Sugarcane Initiative (SSI). A manually operated sugarcane mother shoot cutter was developed, incorporating key components like a main conduit pipe, secateurs, operating lever, handle and handle grip. The tool was designed for use in a standing posture, reducing effort and physical strain. After being evaluated and demonstrated to sugarcane farmers in field conditions, the developed tool proved effective. Weighing only 0.8 kg, it allows operators to work in a standing position with minimal effort. The tool cuts approximately 800 shoots per hour, resulting in a 16% time saving and a 19% reduction in costs. It not only lowers cultivation costs but also reduces human drudgery. The tool's key innovation lies in its simple design, which enables efficient operation while standing, decreasing the risk of injuries associated with traditional tools and eliminating the physical strain commonly encountered during the labor intensive process of mother shoot removal. By aligning with the principles of the Sustainable Sugarcane Initiative, the tool optimizes resource usage and enhances productivity.

Keywords: Cutter; shoots; sugarcane; tool; manual.

1. INTRODUCTION

Sugarcane is cultivated in over 115 tropical and subtropical countries worldwide, covering an area of 26.54 million hectares with an average productivity of 71 tonnes per hectare. India ranks second in the world in terms of sugarcane acreage, following Brazil. In India, sugarcane is grown across 4.5 million hectares, with an average yield of approximately 79 tonnes per hectare. The sugarcane industry supports about 0.5 million workers in sugar mills, along with 7.5 million farmers, and provides employment to a significant number of agricultural laborers involved in cultivation and related activities, making up around 7.5% of the rural population [1].

Tamil Nadu leads the country in sugarcane productivity, with an average yield exceeding 100 tonnes per hectare. However, the output-to-input ratio for sugarcane has been declining due to rising costs of seeds and labor, as well as productivity-related challenges. The Sugarcane Sustainable Initiative (SSI) is a method designed to optimize sugarcane production by using fewer setts, reducing water usage, and minimizing fertilizer and land requirements, thereby enhancing yields through better water, land, and labor productivity. One of the key practices in SSI is the removal of the mother shoot to promote uniform tillering. The plant should be cut approximately 25 mm above the ground once the sugarcane seedlings have been established [2]. This practice encourages the growth of additional tillers [3] and increases the number of millable canes per plant [4].

Traditionally, secateurs, knives, and sickles are used for cutting sugarcane mother shoots. However, these conventional tools are not widely adopted by farmers, as agricultural laborers must bend down, hold the stem and manually cut the mother shoot, which can be physically demanding. The risk of injury to hands and eyes is higher when using these tools, due to sharp spines on the sugarcane stem or the serrated edges of the leaves. Additionally, backaches are common among agricultural laborers during the manual cutting process [5]. The physical strain associated with this task leads to lower productivity, and as a result, there is a growing need to reduce human labor and replace it with machines. Labor for cutting sugarcane is becoming increasingly scarce, as manual cutting is considered strenuous work. The shortage of labor is exacerbated by urbanization and industrialization, which further challenges sugarcane cultivation in India and, ultimately, impacts sugar production in the country [6].

In response to this challenge, a tool has been developed that allows for the cutting of sugarcane mother shoots while standing. This tool has been tested and demonstrated on college farms as well as in farmers' fields. The number of sugarcane mother shoots cut per hour using this tool was analyzed and compared to the efficiency of conventional methods.

2. MATERIALS AND METHODS

The tool is comprised of a main conduit pipe measuring 920 mm in length and 12 mm in internal diameter, along with secateurs, a handle, and a grip handle (Fig. 1). The top portion of the main conduit pipe is bent into an ‘L’ shape, forming the handle, which is 80 mm long and 12 mm in diameter. An 'L' shaped aluminum pipe, 130 mm in length and 12 mm in

diameter, is hinged at the bottom of the handle to operate a wire (1.5 mm in diameter and 1000 mm long) that passes through a 6 mm plastic tube. This wire runs from the operating lever to the tail end of the secateurs. The left handle of the secateurs is clamped 120 mm from the bottom of the main pipe. A 15 mm diameter, 100 mm long mild steel rod is welded to the main pipe 200 mm from the top portion to serve as the grip handle, which is covered with a plastic tube. The front, side, and top views of the developed sugarcane mother shoot cutter are shown in Fig. 2.

Tests were conducted in actual sugarcane fields, 30 to 40 days after planting (DAP) [7], to evaluate the performance of the developed tool and also demonstrated to the benefit of the farmers. The number of mother shoots cut by the tool was recorded after operating it for one hour in different districts of Tamil Nadu. The cost of the tool was determined, and the operational cost was calculated based on the specifications of the Bureau of Indian Standards. Using the collected data, the operational cost of removing the mother shoots for one hectare using the tool was compared to the costs associated with the conventional method.

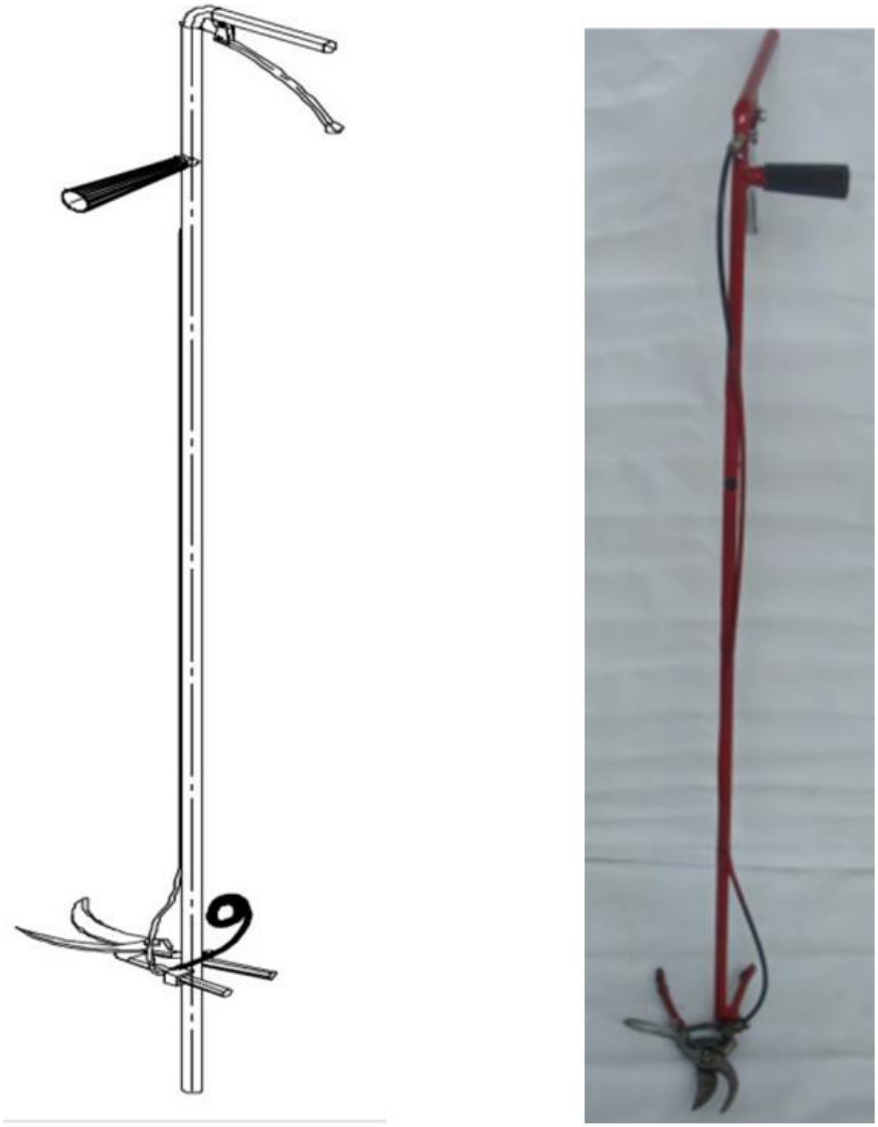

Fig. 1. Manually operated sugarcane mother shoot cutter

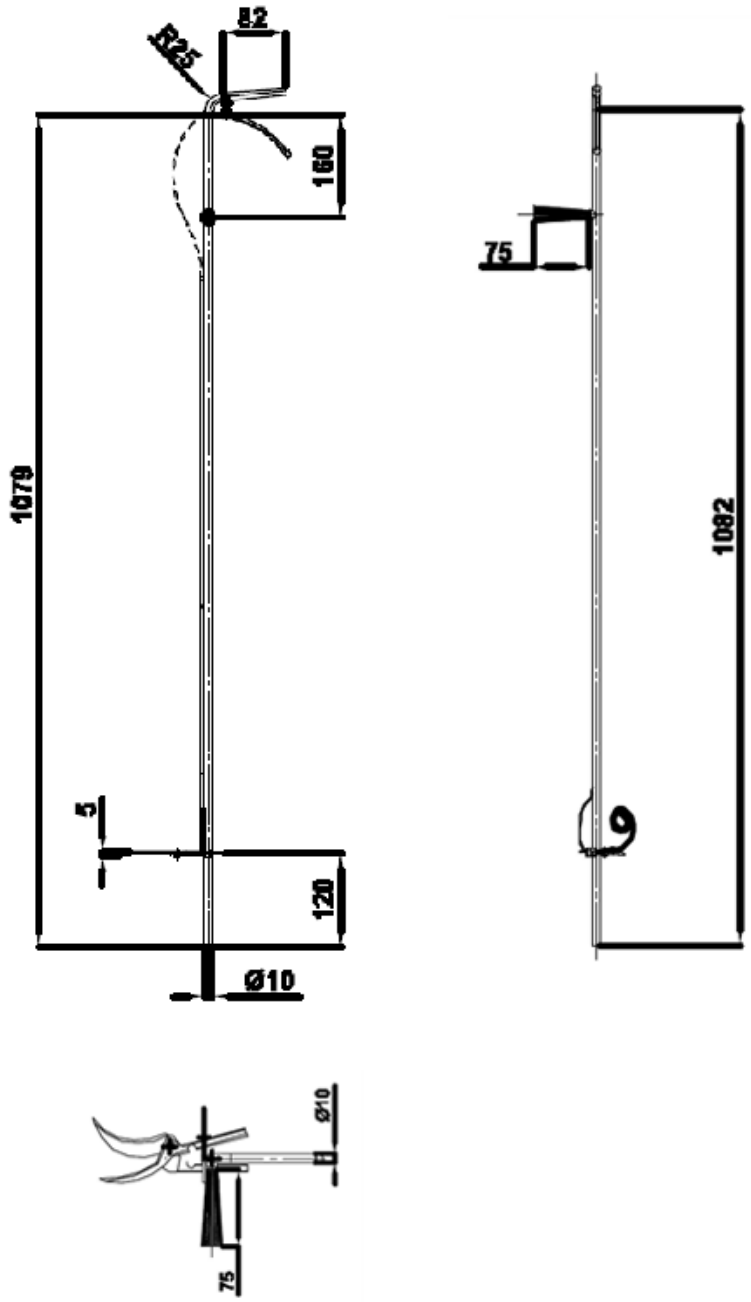

Fig. 2. Manually operated sugarcane mother shoots cutter (2D)

3. RESULTS AND DISCUSSION

The manually operated sugarcane mother shoot cutter was developed at Department of Farm Machinery and Power Engineering workshop in Agricultural Engineering College and Research Institute, Kumulur, Trichy District, Tamilnadu state, India following the specifications outlined in Table 1. Field evaluations of the developed tool were conducted and demonstrated (Fig. 3) at six different locations, including four districts of Tamil Nadu, one month after planting the sugarcane [4] These evaluations took place at two Sugarcane Research Stations (Trichy and Cuddalore), one Krishi Vigyan Kendra (Dharmapuri), one TNAU farm (Coimbatore), and two farmers' fields (Trichy and Dharmapuri). The field observations are summarized in Table 2 and Fig. 4.

Table 1. Specifications of sugarcane mother shoot cutter

S.No.	Particulars	Materials	Dimensions, mm
1	Conduit pipe	Mild steel	920x12
2	Secateurs	Steel casting	200x45x12
3	Operating wire	Steel rope	1000x1.5
4	Rod	Mild steel	100 x10
5	Lever	Aluminum	130x12
6	Handle grip	Mild steel	100x15
7	Handle grip cover	Plastic	80x25
8	Spring	Hardened steel	50x1
9	Overall dimensions, mm	-	950x320x270
10	Weight, kg	0.8	

Table 2. Field performance of sugarcane mother shoot cutter

S.No.	Place	Days after planting (DAP)	No. of mother shoots cuts /h	
			Tool	Manual
1	SRS, Cuddalore (D1)	30	875	700
2	SRS, Trichy (D2)	32	785	680
3	KVK Dharmapuri (D3)	30	804	684
4	TNAU Coimbatore (D4)	35	815	668
5	Puvalur, Trichy (D5)	32	725	616
6	Ayyarkottai, Dharmapuri (D6)	40	795	675

Fig. 3. Field demonstrations of sugarcane mother shoot cutter

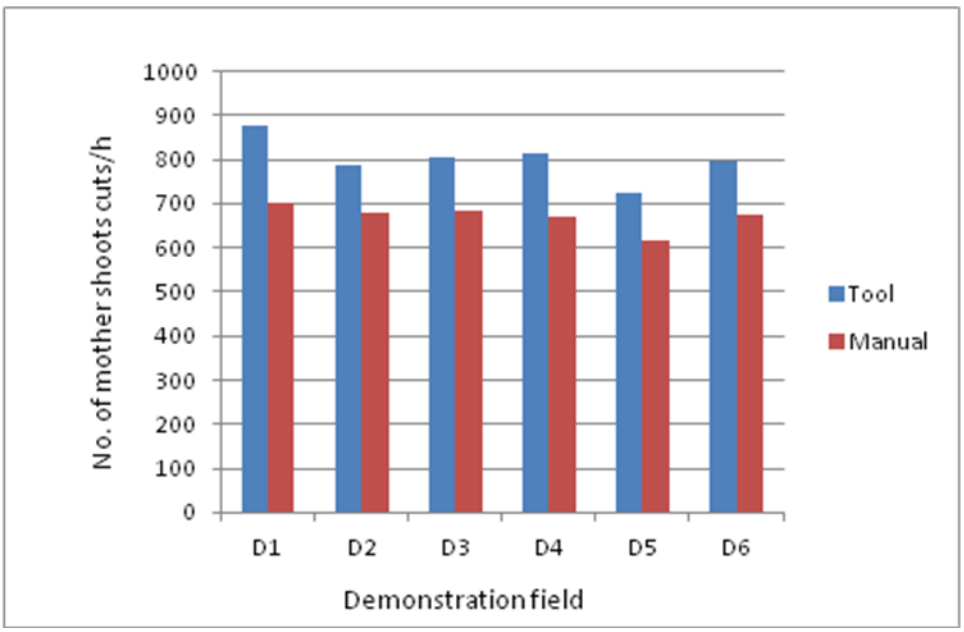

Fig. 4. Performance of sugarcane mother shoot cutter

The tool can be operated in a standing posture, requiring minimal effort and reducing human drudgery due to less weight and simple design of tool. The developed tool and the conventional sickle were able to cut 800 shoots per hour and 670 shoots per hour, respectively. Due to its operation in standing posture, the tool achieve 16% higher cutting efficiency is more compared to conventional method of using a sickle for cutting sugarcane mother shoots [3]. The operational cost for the developed tool was Rs. 744 per hectare, while the conventional tool's cost was Rs. 884 per hectare. The overall dimensions of the tool are 950 x 320 x 270 mm, and its weight is 0.8 kg, making it easy for women to operate in a standing position without difficulty. The tool is lightweight, sturdy, and well-suited for small-scale manufacturing. The cost of the tool is Rs. 720.

4. CONCLUSIONS

This developed tool is used for removing sugarcane mother shoots, aligning with the key principles of the Sugarcane Sustainable Initiative (SSI) to promote uniform tillering and increase the number of tillers per plant. It is portable and can be operated in a standing posture, making it ideal for use in SSI cultivation. The tool helps minimize the risk of injuries to the hands and eyes during the cutting process. Lightweight, durable, and user-friendly, the tool is also easy to manufacture. Compared to conventional tools, it reduces time and costs by 16% and 19%, respectively.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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