Development and Performance Evaluation of Engine-Operated Bund Trimmer

Abstract

Bunds are essential for soil erosion control and irrigation management in agriculture, but maintaining them through manual trimming is labor-intensive and time-consuming. Traditional manual trimming methods are slow and needs more human effort and time. While several bund maintenance tools exist, most are designed for large-scale operations and are not adaptable to smaller fields. This study addresses this gap by developing a power-operated bund trimmer that is efficient, cost-effective, and suitable for small and medium-scale farming operations. The trimmer is powered by a 1.5 hp petrol engine and is designed with a rotary disc, cutting blades, power shafts, a safety guard, and a handle. It is operated by two individuals, one to carry the engine and the other to manage the trimming operations. The machine was tested on dry and wet cultivable lands to evaluate its performance in terms of operational speed, time efficiency and area covered. The bund trimmer demonstrated an effective working capacity of 8.6 m/min in dry land and 15.7 m/min in wetland, significantly outperforming manual trimming methods, which yielded only 6 m/min and 10 m/min, respectively. Operating at 1600 rpm, the trimmer effectively cuts through both soil and weeds. The operational cost was Rs. 454 per day, providing a cost-effective solution for bund maintenance. The machine is most effective for bunds under 300 mm in height and offers a practical alternative to manual methods, reducing labor time and increasing operational efficiency, making it suitable for regular bund maintenance in small and medium-sized farms.

Keywords: bund, trimmer, soil, weeds, cultivable land

1.INTRODUCTION

Agriculture has long been the primary occupation of rural communities, largely relying on human labor. However, as the global population increases, human power alone can no longer meet the demands of modern agricultural practices. This has led to a natural increase in the need for farm mechanization. Key agricultural tasks, such as grass cutting and bund trimming, are essential for crop management and mechanized solutions are now frequently employed to improve efficiency.

Bushes are commonly found in many areas, particularly after rainfall, creating obstacles for machinery, bullocks, and even humans (Chavda et al., 2022). One of the most costly and time-consuming tasks occurs when dense undergrowth, primarily made up of weed species, covers the bunds. It has been observed that farmers tend to rely on simple hand tools for bush cutting and few efforts have been made to develop indigenous mechanized solutions for this task (Nadre et al., 1992; Stoddard, 1937).

Grass cutting machines come in various types, including mowers, rotary and mulching mowers, hover mowers, riding mowers, and professional mowers. However, these machines are often expensive and unaffordable, requiring skilled operators (Magar et al., 2010). Farmers continue to struggle with the challenge of managing weeds, which not only depletes valuable resources but also diminishes productivity (Magar et al., 2010). While traditional engine-powered lawn cutters are effective, they have a considerable environmental impact due to their noise pollution and harmful emissions (Sanket et al., 2016). However, amid this ongoing challenge, a quiet revolution is unfolding.

Bund preparation a critical operation in agriculture, involves creating embankments around fields to manage water flow and prevent soil erosion. Traditionally, bund preparation has been performed manually through trimming (Singh et al., 2017). Bund trimming is traditionally carried out by manual laborers, as it is an essential operation for maintaining bunds in agricultural fields. Every season, bunds require trimming to ensure they are effective in controlling water flow and preventing soil erosion. However, one of the key challenges faced by farmers is the creation of holes in the bunds, often caused by pests such as rats, crabs and other animals. These holes allow water to flow from one field to another, leading to irrigation imbalances, water loss and potential crop damage. Proper maintenance of bunds, including sealing these holes, is crucial for preventing such issues (Joshi et al., 2019; Sharma et al., 2018).

Due to the formation of holes in agricultural bunds, essential inputs such as fertilizers, herbicides, and nutrients are often lost, as water can flow out of the fields and carry these substances with it. This not only leads to the wastage of valuable agricultural inputs but also disrupts the efficiency of irrigation systems. To mitigate this, farmers often consolidate the loose bunds by filling the holes and repairing any damage. Additionally, weeds growing along the sides of the bunds are manually removed using spades to ensure the bunds remain intact and effective. This labor-intensive process is essential for maintaining the structural integrity of bunds and preventing further water loss from seeping between fields, but it also highlights the ongoing challenge of managing bunds in a way that minimizes resource waste (Sahu et al., 2021).

If the weeds growing along the sides of bunds are not cleared, they can create several problems, such as competing for water, nutrients and fertilizers with the main crop cultivated in the field. This competition can negatively impact crop growth and yield. However, manual trimming using a spade presents significant challenges for farmers. The process is physically demanding, leading to fatigue and reduced efficiency as farmers tired quickly due to the high energy expenditure. Moreover, manual trimming allows for only limited coverage in terms of length, making it a time-consuming task. As a result, the need for mechanized solutions to streamline this operation has become increasingly apparent (Singh et al., 2017; Mukesh et.al 2022).

Bund trimming is a labor-intensive task that local farmers have been practicing manually for centuries. It is typically carried out in two key steps at the beginning of each crop season. The first step involves clearing the bunds of weeds and grass during the initial ploughing. This is crucial, as the weeds can compete with the main crop for water, nutrients, and sunlight. After this, during the second ploughing, the bund is plastered with a layer of mud to reinforce its structure and prevent water leakage. These manual practices have been essential for maintaining bunds and ensuring proper irrigation, but they also require significant physical labor and time, which can be challenging for farmers, especially with increasing land size and labor shortages (Jain et al., 2017).

Good bunds play a crucial role in limiting water losses caused by seepage and under-bund flow. To maintain bund integrity, they must be well compacted and any holes created by rats or other pests should be plastered with mud. The main objective, therefore, is to mechanize the bund trimming process, as this would provide significant benefits to farmers by saving time, reducing physical labor and making their work more efficient (Nanjundan and Srinivasan 2018; Jadhav and Yadav 2019).

Bund trimming is a physically demanding and time-consuming task that involves considerable human drudgery, labor costs, and energy expenditure. An ordinary skilled man can trim and plaster 90-120 m of bund per day. Due to the high labor input required and the increased demand for agricultural production, there is an urgent need for the development of indigenous, portable bund trimmers to alleviate these challenges and improve the productivity of farmers (Patel et al., 2020).

2. MATERIALS AND METHODS

The engine-operated bund trimmer (Fig.1) is a modified version of a commercially available brush cutter, which is a handheld device typically used for trimming bunds. It features a cutting head at the end of a long, rigid power shaft, along with a handle and shoulder strap for ease of use. Powered by an internal combustion engine, the bund trimmer has the engine positioned at the opposite end of the shaft from the cutting head. This machine runs on a petrol engine. The main components of the bund trimmer include the flexible power shaft, handle, rigid power shaft, safety guard, gear box, rotary disc, cutting blades and scraper.

Fig. 1. Engne Operated Bund Trimmer

The 1.5 hp petrol engine serves as the prime mover for the bund trimmer. The engine is connected to the rigid power shaft via a flexible shaft, which is equipped with suitable flanges and screws for secure attachment (Fig.2). The flexible shaft transmits rotary motion from the engine to the rigid shaft, allowing easy movement of the cutting end in the desired direction. The flexible shaft has a length of 870 mm, a diameter of 20 mm.

A J-shaped handle (Fig.3) is attached to the rigid power shaft to facilitate easy gripping and maneuvering of the machine without strain. The handle is made of plastic, with a diameter of 23 mm and a length of 450 mm. The rigid power shaft connects the rotary disc to the flexible shaft, transmitting power from the flexible shaft to the rotary disc. The rigid shaft has a length of 925 mm and a diameter of 22.5 mm.

The power reduction from the engine to the main shaft is 3:1 and the power is further reduced to the rotary disc. The cutting blade (Fig.4) is a small metal piece which welded in rotary disc for trimming the bunds. The dimensions of the cutting blade are 40 mm and 20 mm. To ensure operator safety, a safety guard (Fig.5) is included to prevent sand from spilling onto the operator during use. The safety guard is made of mild steel and has a rectangular shape with dimensions of 350 mm and 220 mm.

			
Fig.2 Flexible power shaft	**Fig.3 J shape Handle**	**Fig.4 rotary disc with cutting blade**	**Fig.5 Gear box and safety guard**

The performance of the engine-operated bund trimmer was evaluated in farmer's field and at Agricultural Engineering College and Research Institute, Kumulur. The tests were performed at two sizes of rotary discs, three levels of speeds (1000, 1300, and 1600 revolutions per minute) and three levels of cutting blades (2, 4, and 6 numbers) in bund in the agricultural field. The bund trimming efficiency was measured after operating the machine for one hour in field's bund.

A digital tachometer was used to measure the rotational speed of the engine crankshaft, while a stopwatch was used to record the time taken. The operational cost and machine cost were calculated according to the specifications of the Bureau of Indian Standards. Based on the collected data, the operational cost of trimming a one meter bund using the machine was calculated and compared with the conventional method. The machine required two operators: one to carry the engine at the rear and the other to operate the trimmer. The operator should hold the handle at a comfortable position, typically around hip height, during the trimming operation.

3. RESULT AND DISCUSSION

The developed bund trimmer, trial was conducted at college farm, with 225 mm rotary disc and two cutting blades which results poor performance. To enhance efficiency, the number of cutting blades was increased to four, which led to moderate performance. Further attempts were made to improve the cutting efficiency by increasing the number of cutting blades to six (Fig.6 &7). However, when engaging with hard soil, an overload occurred, damaging the gear assembly (AG4). To address the issue of load variations, the gear assembly was replaced with larger gears (AG5) designed to withstand higher loads. This improved the performance of the blade. However, when trimming bunds with high elevation, the operator needed to move the rotary disc up and down to achieve uniform trimming.

To resolve this issue, a trial was conducted with a 300 mm mild steel (MS) blade. The increase in diameter resolved the problem of shifting the trimmer up and down. The 300 mm MS blade was operating at 1000, 1300 and 1600 rpm. Among these speeds, 1600 rpm proved to be the most efficient in terms of performance. At 1600 rpm, the machine covered a larger area compared to manual trimming, which can only trim a smaller area. While the diameter of the rotary disc did not significantly affect the length of the coverage, for bunds taller than the usual height (up to 300 mm), a larger diameter of rotary disc with 6 cutting blades proved to be more efficient. The performance of the bund trimmer is given in table 1. The small arrangement was made to reduce heat buildup by inserting a rubber cork between the shaft and engine. Additionally, the engine is inclined at a 45º angle, which helps minimize vibration and heat dissipation, making the machine more comfortable for the operator to use.

Table 1. performance of bund trimming with different variables.

Parameters	**Rotary disc, mm**		**Number of blades**			**Speed, rpm**		
	225	**300**	**2**	**4**	**6**	**1000**	**1300**	**1600**
Cutting efficiency in dry land, m/min	8.3	8.6	Poor	Moderate	Good	Poor	Moderate	Good
Cutting efficiency in wet land, m/min	15.5	15.7	Moderate	Good	Excellent	Moderate	Good	Excellent

The moisture content of the soil in dry land and wetland was 8% and 12%, respectively. Using a 300 mm diameter rotary disc with 6 cutting baldes, the developed machine was able to trim bunds at a rate of 930 m/h in wetland and 500 m/h in dry land. In comparison, the manual method of trimming using a spade achieved trimming rates of 72 m/h in wetland and 54 m/h in dry land. The operational cost of using the bund trimmer is Rs. 454 per day.

The machine reduces human drudgery, as it allows the operator to work in a standing posture without difficulty. It not only saves time but also reduces operational costs, making it a more efficient alternative to manual bund trimming.

4. CONCLUSION

In terms of performance, manual trimming with a spade achieved trimming rates of 10 m/min in wetland and 6 m/min in dry land. However, compared to manual methods, the bund trimmer significantly improves efficiency, with field coverage of 15.7 m/min in wetland and 8.6 m/min in dry land. The diameter rotary disc did not significantly affect the length of bund trimming. The operational cost of using the bund trimmer is Rs. 454 per day.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest: Authors do not have any conflict of interests to declare..

Ethical issues: None

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.

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Fig.6. Performance evaluation of triming of bund in dry land

Fig.7. Performance evaluation of triming of bund in wed land