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ORIGINAL ARTICLE

Performance Assessment of the Small and Medium-Scale Coconut Weeder Cum Fertilizer Applicator Developed by Rajarata University of Sri Lanka

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Abstract

The enhancement of coconut yield significantly hinges on proper weeding and chemical fertilizer application. In Sri Lanka, several mechanical methods have been introduced for weeding and fertilizer application of coconut, but the traditional manual approach persists most popular, despite being time, labor cost intensive. Moreover, the introduced technologies were suited for large-scale coconut cultivation and could not cope with medium or small-scale. Furthermore, most of them are designed for a single application; weeding or fertilizing. Thus, the Faculty of Agriculture, Rajarata University of Sri Lanka (RUSL), developed a coconut weeder cum fertilizer applicator for medium and small-scale coconut cultivations. However, it has not been properly evaluated and recommended for farmers. Consequently, this study sought to evaluate the performance of the above machine by conducting a comparative performance evaluation with the conventional method. A healthy, well-maintained, proper-spacing coconut plantation was selected from the faculty research unit, and each weeding and fertilizer application method was replicated ten times. In terms of performance parameters: effective field capacity, field efficiency, and weeding efficiency in mechanical and manual methods were 0.172 ha h-1, 61.86%, 66.62%, and 0.048 ha h-1, 55.34%, 60.35%, respectively. Statistical analysis indicates the mechanical method had higher field capacity and efficiency than the manual method, while weeding efficiency was not significantly different ($p \leq 0.05$). In addition, the machine had a fertilizer spreading uniformity of around 99.98% when operating at an optimum speed of 1.45 km h-1. Fertilizer application rate and performance index as a weeder were 1.7 kg/min and 1145.86, respectively. Furthermore, the fuel consumption rate of the machine was 0.733 L h-1 and its break-even point was recorded as 2.85 ha yr-1. Consequently, the coconut weeder cum fertilizer applicator proves suitable for medium and small-scale coconut cultivations in Sri Lanka.

Keywords: *Break-even point, Coconut cultivation, Manuring, Performance evaluation, Weeding*

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1. Introduction

The coconut tree is referred to as the "Tree of Life" due to its immense versatility and the wide array of benefits offers to humans. Every part of the coconut tree, from its roots to its fronds, finds a multitude of uses, besides it making an invaluable resource for communities around the world (Debmandal and Mandal 2011). Indonesia, Philippines, India, Malaysia, Sri Lanka, Thailand, and Vietnam are the world's leading coconut-producing countries, and the Asia Pacific region accounts for 87% of global coconut production (Smith et al. 2009). Sri Lanka stands out as the world's 5th largest producer of coconuts, boasting expansive plantations covering approximately over 394,000 hectares, contributing significantly to the agricultural landscape and the national economy (Kamaral et al. 2014). In 2019, the coconut industry contributed 0.7% to the country's GDP, highlighting its importance as a source of income and employment for millions of Sri Lankans (CBSL 2020).

In Sri Lanka, the major coconut-growing region is known as the "coconut triangle," encompassing nearly 61% of the total coconut cultivation area. The coconut industry in Sri Lanka is predominantly characterized by smallholder ownership, with over 82% of coconut holdings managed by individual farmers or small-scale enterprises (Pathiraja et al. 2010). This highlights the widespread impact and importance of coconut cultivation on the livelihoods of Sri Lankan communities.

One of the predominant challenges facing the coconut sector in Sri Lanka is the persistent gap between the high demand for coconuts and the limited supply, as highlighted by Bandara and Kumari (2020). In 2019, Sri Lanka witnessed a total coconut production of 3,086 million nuts, as reported by the Central Bank of Sri Lanka (2020). While recommended coconut cultivars have the potential to yield between 12,000 to 15,000 nuts per hectare under ideal conditions, the national average falls significantly lower, ranging between 6,000-6,250 nuts per hectare. This disparity is attributed to suboptimal management practices, issues with fertilizer application, and adverse climatic conditions (Norica et al. 2021).

Coconut palms need a balanced supply of essential nutrients for healthy growth. These include the main nutrients: nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. Additionally, they require small amounts of micronutrients like boron, copper, iron, manganese, molybdenum, and zinc. These nutrients play essential roles in various physiological processes within the coconut palm, influencing growth, nut development, and resistance to diseases and pests. Plant nutrients are continuously removed from coconut palms through the production of nuts, husks, fronds, and other materials in the crown (Coconut Research Institute 2018). However, their productivity and the quality of their produce are heavily dependent on the availability of essential nutrients. Therefore, proper fertilizer application is crucial for maintaining the health and vigor of coconut palms, ensuring optimal nut production. The most effective way to apply fertilizers to coconut palms is by covering the entire soil area beneath the canopy of the palm and mixing it with the soil (usually about 450–

500 sq. ft) (Broschat and Crane 2000). This method, known as ring application or broadcasting following the incorporate with soil, ensures that the nutrients are distributed evenly and reach the palm's root system for efficient uptake. Unlike surface application, which is prone to issues such as volatilization, leaching, washout, and erosion, the soil-mixing technique ensures a more efficient nutrient delivery system (Randall and Hoeft 1988). This strategic approach underscores a commitment to sustainable and effective nutrient management practices for coconut cultivation.

Despite the introduction of various fertilizer application methods, small and medium-scale coconut cultivators in Sri Lanka have traditionally relied on a labor-intensive, time-consuming, and costly approach that involves loosening the soil with a mamoty around the plant and mixing fertilizer with the soil. This manual method not only demands significant labor input but also fails to achieve uniform fertilizer distribution around the palm (Fernando et al. 2013). While large-scale coconut cultivators often employ tractor-coupled, fertilizer deep placement implements, these machines come with high capital and operational costs, particularly when intercrops and cover crops are present within the coconut cultivation setup crate an extra manipulation burden.

The Faculty of Agriculture, Rajarata University of Sri Lanka has developed a coconut weeder cum fertilizer applicator. This innovation This approach delivers fertilizer to coconut plants and controls weeds at the same time. Anticipated to gain popularity among small and medium-scale coconut cultivators in Sri Lanka, especially those cultivating intercrops and cover crops within their coconut fields, this technology stands out for its effectiveness and cost efficiency. This apparatus is a modified attachment for commercially available bush cutter with weeder attachment, which is widely spread among small and medium scale coconut farmers in Sri Lanka (Abeywardhana and Weerasooriya 2020).

This study aimed to evaluate the functionality and efficiency of the coconut weeder cum fertilizer applicator. Furthermore, the study conducted a comparative performance evaluation of this coconut weeder cum fertilizer applicator against with the traditional manual method used in coconut cultivation. The intended outcome is to recommend a more effective, convenient, and economically viable weeder cum fertilizer applicator, for medium and low scale farmers, thereby contributing to increased coconut productivity while reducing production costs in the Sri Lankan context.

The coconut weeder cum fertilizer applicator has four main parts: a power source, a weeder attachment, a hopper, and a fertilizer metering mechanism. Components of the coconut weeder cum fertilizer applicator are shown in Fig.1- 2.

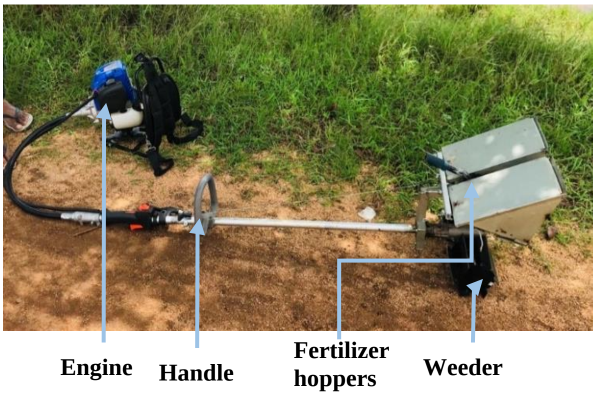


Figure 1. Components of coconut weeder cum fertilizer applicator

(a) (b)

Figure 2. Weeder cum fertilizer applicator
***(a)** – Side view*, ***(b)**- Rare view*

The coconut weeder cum fertilizer applicator is powered by a one horsepower, 4-stroke gasoline, and air-cooled engine. This engine is linked to the weeder attachment, a component commonly available with bush cutters and in direct contact with the soil. There are two weeder attachments, each equipped with six flat, sturdy blades made of mild steel (Kahandage 2021), that blades rotate as the machine works, helping to loosen soil, slash weeds, and blend fertilizer into the soil.

The fertilizer applicator has two triangular hoppers made of galvanized metal sheets (4 mm thickness) that temporarily hold the fertilizer. Each hopper can store up to 3025 cm^3 of fertilizer. These hoppers are designed to supply 3-5 kg of fertilizer mixture for a single plant (Kahandage 2016) (Fig. 3.).

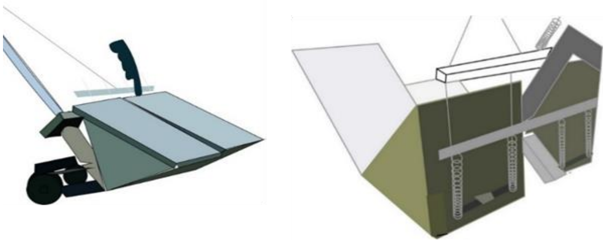


Figure 3. Fertilizer hopper of the coconut weeder cum fertilizer applicator

Before proceeding with the evaluation process, minor modifications were made to address the drawbacks of the previously existing fertilizer-releasing mechanism. These modifications were targeted at improving both the uniformity of fertilizer release and the prevention of bulk fertilizer discharge, as discussed in the methodology section.

2. Materials and Methods

The coconut weeder cum fertilizer applicator undertook modifications and fine-tuning at the Engineering Workshop in the Faculty of Agriculture, RUSL. Subsequently, its performance was tested and assessed in a well-maintained coconut plantation within the faculty research unit at the same institution. This plantation is situated in the DL1b agroecological region at coordinates 8°25'18.12" latitude and 80°24'9.37" longitude, characterized by an undulating catenary landscape. The study area features perfectly drained Reddish-Brown Earth soils classified as Alfisols (Suborder: Ustalfs, Great Group: hapludalfs) according to soil taxonomy (Wickramasinghe et al., 2023). The predominant soil texture in this region is sandy loam (Attanayake et al., 2022)

Modifications:

At the bottom of each hopper, a Variable Orifice Fertilizer Metering Mechanism (VOFMM) has been integrated to facilitate the distribution of fertilizer. This mechanism is controlled by a unit comprising a flexible cable with a lever and spring-loaded adjustable metal plate. Prior to operation, the appropriate width of the orifice is determined by selecting one of three different-sized metal plates (4, 8, 10 cm), which can be inserted into the bottom of the hopper.

The lever, functioning akin to a gear shifter, is connected to the spring-loaded metal plate, enabling the adjustment of the orifice's height.

This adjustment regulates the delivery of fertilizer while the machine is in operation. (Fig. 4.)

These modifications to the coconut weeder cum fertilizer applicator have been implemented to replace the previously existing fertilizer releasing mechanism, allowing for precise and efficient delivery of fertilizer through the adjustment of both the height and width of the orifice.

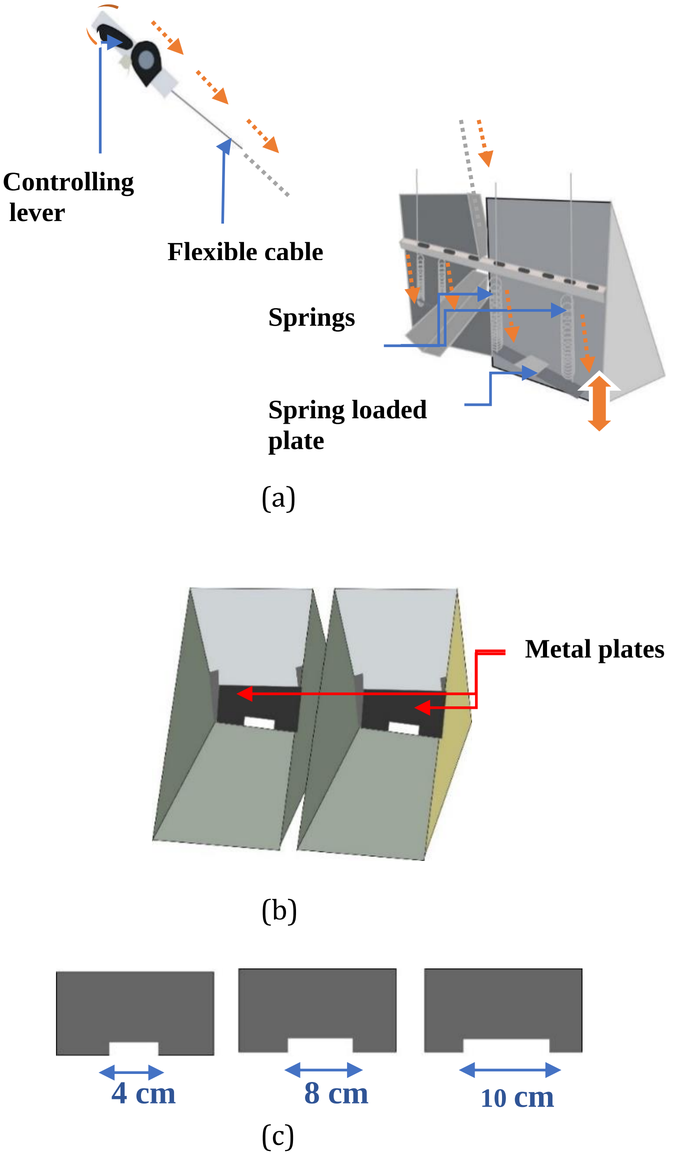


Figure 4. Variable Orifice Fertilizer Metering Mechanism (VOFMM) (a) Height controlling mechanism, (b) Width controlling mechanism, (c) Different sizes of metal plates.

Test conditions:

Prior to the evaluation, laboratory tests were conducted to identify the physical and operational characteristics of the weeder cum fertilizer applicator, determining its overall dimensions. Besides that, the field's soil attributes, and environmental conditions were examined to establish the testing parameters.

As the machine parameters; height, width, length, weight (with fertilizer and without fertilizer), and capacity of the hopper were measured. As soil parameters; soil moisture content (% dry weight basis), bulk density (g cm^{-3}) and soil hardness were assessed by using gravimetric method, core sampler method and cone penetrometer respectively. Concurrently, atmospheric conditions in the test field; air temperature, wind speed, humidity, and rainfall were recorded.

The specifications of the modified coconut weeder cum fertilizer applicator, slated for evaluation, are outlined in Table 1.

Table 1. Specifications of the machine

Machine Parts	Specifications	Values
Overall machine	**Width (cm)**	**35**
	Height (cm)	124
	Length (cm)	150
	Weight (kg)	17
	Source of power	Petrol engine
	No of operators	One
	Depth of fertilizer application (cm)	2.5 – 3.5
Engine	Type	4 strokes, Air cooled, OHV
	Weight (kg)	8
	Type of fuel	Petrol
	Fuel tank capacity (ml)	700
	Power (hp)	1
Hopper	No of hoppers	Two
	Capacity of each hopper (cm^3)	3025
	Shape of hopper	Triangular
	Height (cm)	20
	Length (cm)	20

	Width (cm)	15
Weeder attachment	Diameter (cm)	12
	No of wheels	2
	No of blades per wheel	6
	Blade length (cm)	14
	Blade width (cm)	3

Performance evaluation:

Following the RNAM (1983) test codes and procedures, the coconut weeder cum fertilizer applicator underwent field performance evaluation. For comparative assessment, 20 healthy, well grown coconut palms of the same age (5 years old) were chosen, and these palms were situated within a 32x40 meters rectangular plot, adhering to the spacing recommendation of 8x8 meters as stipulated by the Coconut Research Institute (CRI) guidelines in Sri Lanka. Skilled laborers and machine operators were assigned for the evaluation.

The testing and evaluation process involved two distinct treatments, each treatment was replicated 10 times, with 10 separate plants assigned to each replication.

T_1 – Application of fertilizer manually using mamoty

T_2 – Fertilizer application by coconut weeder cum fertilizer applicator

In the mechanical method, the machine applied fertilizer by circling on the manure cycle at an optimized speed of 1.45 km/h, discovered at the preliminary tests. Meanwhile, in the manual method, the recommended fertilizer amount was spread around the palm (about a 1 to 1.2 m radius) and mixed with soil using mamoty manually.

Throughout the evaluation process, several parameters were recorded, including the time required to apply fertilizer and weeding per tree (excluding time losses such as resting, adjustments, moving, and turning) (min), time losses instead of applying fertilizer and weeding (resting, adjustments, moving, turning) (min), average depth of application, and amount of weed slashed/removed during the process were recorded.

As per RNAM (1983) test code procedure, the machine performance parameters; effective field capacity (EC), theoretical field capacity (TC), field efficiency (E), effective fertilizer application rate (EFR), and fuel consumption were calculated.

The weeder's performance index was calculated by Eq. 1 (Weerasooriya et al. 2017).

$$\text{Performance Index} = \frac{\text{Field capacity} \times (100 - \text{Plant Damage Percentage}) \times \text{Weeding efficiency}}{\text{Power(hp)}}$$

(Eq. 1)

Weeding efficiency was assessed using the weed counting method separately for treatments T_1 and T_2. A 50 cm^2 quadrant was randomly positioned within the manure circle, and counts were conducted for grasses, sedges, and broad leaves within these quadrants both before and after the weeding process. weeding efficiency (WE) was calculated using Eq. 2 (Weerasooriya 2022).

$$WE = \frac{N_b - N_a}{N_b} \times 100$$

(Eq. 2)

Where,

N_b - No. of weeds before weeding

N_a - No of weeds after weeding

To assess the consistency of fertilizer distribution from a weeder cum fertilizer applicator, the machine was initially prepared for operation, and the amount of fertilizer in the hopper was noted and the operational cycle was divided into four equal parts. The machine was run in one quadrant, and the remaining fertilizer in the hopper was measured after completion. This process was repeated for all four quadrants. Using a proportional allocation method, the percentage of fertilizer spread in each quadrant was calculated using Eq. 3.

$$DU = \frac{M_b - M_a}{M_t} \times 100$$

(Eq. 3)

Where,

DU - Percentage of fertilizer spreaded on the individual quadrant (%)

M_b - Amount of fertilizer in the hopper before starting each quarter (g)

M_a - Amount of fertilizer in the hopper after operated machine each quarter (g)

M_t - Amount of fertilizer applied per plant (g)

Economic performance evaluation:

To compare the expenses involved in manual versus mechanical methods for fertilizer application and weeding, the cost elements for each method were computed separately. For the mechanical approach, fixed costs comprise depreciation, interest, insurance, taxes, housing, repairs, and maintenance. However, insurance, taxes, interest, and housing were considered negligible for the machine. The machine's salvage value was estimated at 10% of its production cost, and its expected useful lifespan was set at 7 years. Depreciation (LKR yr^{-1}) was determined via the straight-line method. Fixed, variable, and annual costs were calculated according to the RNAM procedure (RNAM 1983).

The variable costs for the mechanical method comprised expenses for fuel, lubricant, and labor, all directly correlated with the machine's workload. Fuel expenses were calculated based on hourly fuel consumption and the prevailing market rate. Lubricant costs were estimated at 10% of the fuel expenses and labor charges were determined according to the prevailing daily wage rate.

The total cost of operation was calculated using Eq. 4 (Weerasooriya et al., 2016).

$$C = F_c + F + O + L$$

(Eq. 4)

Where,

C – Cost of operation ($\mathrm{LKR\ h^{-1}}$)

F_c – Hourly fixed cost ($\mathrm{LKR\ h^{-1}}$)

F – Fuel cost ($\mathrm{LKR\ h^{-1}}$)

O – Lubricant cost ($\mathrm{LKR\ h^{-1}}$)

L – Labour cost ($\mathrm{LKR\ h^{-1}}$)

To obtain the fertilizer application and weeding cost per area, the total hourly cost is divided by the field capacity of the implement.

In the case of the manual method, there were no fixed costs involved. The only cost component considered was labor wages, which acted as the variable cost.

The break-even point represents the annual operational capacity required for the machine to validate its ownership. It is calculated using Eq. 5 as outlined in RNAM (1983).

$$B_e = \frac{F_c}{V_{ct} - V_m}$$

(Eq. 5)

Where,

B_e- Break-even point (ha yr^{-1})

F_c- Fixed cost (LKR yr^{-1})

V_{ct}-Variable cost for manual fertilizer application (LKR ha^{-1})

V_m- Variable cost for fertilizer application by fertilizer applicator (LKR ha^{-1})

Data analysis:

Calculated effective field capacities, field efficiencies, and weeding efficiencies for both manual and mechanical methods were analyzed using a two-sample t-test (P≤0.05) via IBM SPSS Statistics software.

3. Results and Discussion

Test field conditions:

The chosen field soil exhibited an average soil bulk density of 1.69 gcm^{-3} and a moisture content of 7.86%, respectively. However, this moisture content is insufficient for optimal fertilizer absorption and dispersion. Therefore, prior to applying fertilizer, the soil was moistened to achieve suitable moisture levels (Abid Subhani et al., 2012) Moreover, the recorded average soil hardness or resistance in the field was 123.9 $\times 10^4$ Nm^{-2}. These soil parameters play a crucial role in determining the ease of soil loosening, mixing, and the effectiveness of weeding processes. During the evaluation, the ambient conditions in the test field were recorded as follows: temperature, relative humidity and wind speed were 31 °C, 66%, and 1 ms^{-1}, respectively.

Comparative performance evaluation for coconut weeder cum fertilizer applicator with manual method :

Effective field capacity

As per the results illustrated in Fig. 5, the average effective field capacity for manual fertilizer application was 0.048 ha h^{-1} (±0.0008), whereas for the mechanical method using the coconut weeder cum fertilizer applicator, it stood at 0.172 ha h^{-1} (±0.0069). The manual method showed a significantly lower effective field capacity compared to the mechanical approach (p = 8.124e-13). Manual operations, usually using mamoty, proved to be tiring and more time-consuming compared to the mechanical fertilizer application with rotary wheel operating at speeds between 850-1650 rpm, driven by an engine running at 7500 rpm.

However, various studies have different outcomes regarding the machine's performance. Previous research on similar machines reported an effective field capacity of 0.26 ha h^{-1} (Abeywardhana and Weerasooriya 2020), a notably higher value compared to the recent study. Hasan et al. (2018) developed a manually pushed urea super granule applicator, reporting a capacity of 0.16 ha h^{-1}, aligning more closely with the presently observed values. Additionally, Alam et al. (2014) designed a pull-type two-row granular urea applicator, which reported a much lower effective field capacity of 0.11 ha h^{-1} compared to the current study. This coconut weeder cum fertilizer applicator showcases multitasking abilities beyond these machines, as it efficiently applies fertilizer while simultaneously performing weeding operations.

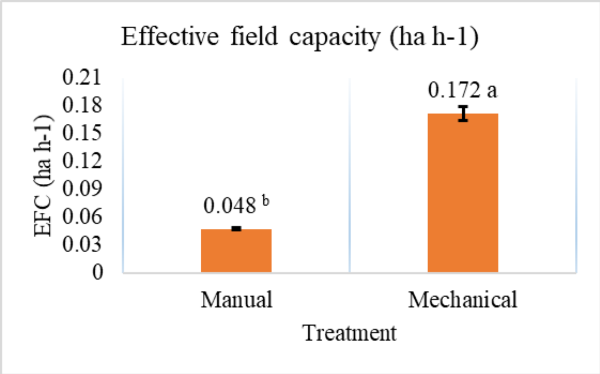


Figure 5. Average effective field capacity for manual and mechanical methods

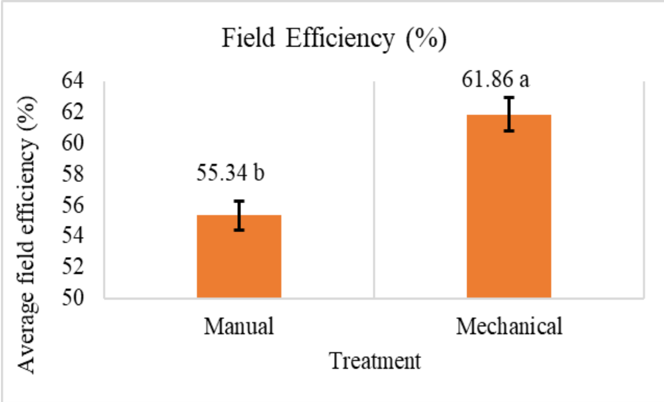


Figure 6. Average field efficiency for manual and mechanical method

Field efficiency

The average field efficiency for manual fertilizer application stood at 55.34% (±0.94), whereas for the mechanical method using the coconut weeder cum fertilizer applicator, it reached 61.86% (±1.09). Fig. 6 revealed a significant difference between the field efficiencies of the two methods (p = 0.0003), with the mechanical application showcasing the highest efficiency.

A previous study by Abeywardhana and Weerasooriya (2020) reported a field efficiency of 60.02% before the machine's modification, which aligns with the current findings. However, diverse field efficiency values are documented in various studies. For instance, Alam et al. (2014) introduced a pull-type two-row granular urea applicator with an effective field capacity of 78.89%. In another study, Hasan et al. (2018) developed a manually pushed urea super granule applicator, achieving a higher field efficiency of 88.1% compared to the present study.

Weeding efficiency

Based on the findings depicted in Fig.7, average weeding efficiency for manual fertilizer application and mechanical fertilizer application by coconut weeder cum fertilizer applicator were calculated as 60.35% (±2.08) and 66.62% (±2.33), respectively. These results indicated no significant difference in weeding efficiency between the manual and mechanical application methods (P=0.06029). Although, Fig. 7 clearly illustrates that the mechanical method exhibits higher weeding efficiency than the manual method, particularly at its optimum speed level. It is worth noting that speed also plays a crucial role in influencing weeding efficiency, with optimum speed operation resulting in higher weeding efficiency for the mechanical method.

Comparing findings with a previous study on the same machine without modification, which reported a weeding efficiency of 59.6% (Abeywardhana and Weerasooriya 2020), that current study exhibits a slightly higher weeding efficiency. Additionally, Manjunatha et al. (2014) developed a manually operated sprocket weeder with a reported weeding efficiency of up to 94.5%, and Olaoye and Adekanye (2006) designed a rotary power weeder with a weeding efficiency of 73%. These values significantly exceed the weeding efficiency observed in our present study.

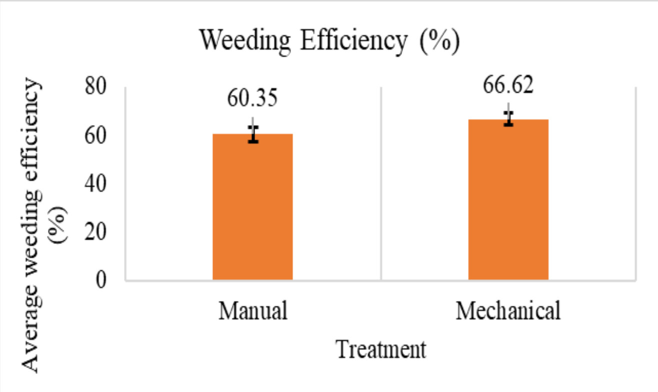


Figure 7. Average weeding efficiency for manual and mechanical method

Examining the calculated weeding efficiencies across different weed types, (Figure. 8), manual weeding emerges as the more effective approach for dealing with sedges and grasses, while the mechanical method is more effective for broad-leaved weeds. The data suggests that the mechanical implement is most suitable for dealing with broad-leaves weeds, which have easily breakable stems and roots. The rotating weeder attachment makes it easier to slashed or escaped from the soil.

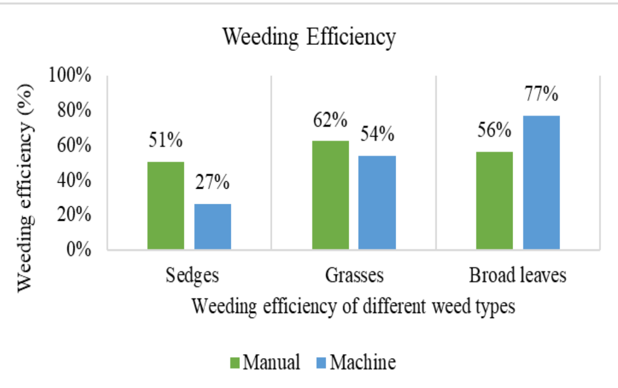


Figure 8. Average weeding efficiency of different weed types for manual and mechanical methods

Performance evaluation for coconut weeder cum fertilizer applicator:

Effective fertilizer application rate (EFR)

The coconut weeder cum fertilizer applicator distributing fertilizers at an impressive Effective Fertilizer Application Rate (EFR) of 1.7 kg/min. This not only underscores its effectiveness in fertilizer application but also reduces operational time significantly.

Fuel consumption of the machine

The recorded fuel consumption rate for the machine was 0.733 L h^{-1}. In a previous study on the same coconut weeder cum fertilizer applicator prior to the modifications by Abeywardhana and Weerasooriya (2020), reported fuel consumption as 0.82 L h^{-1}, showing a close similarity with the findings of the present study.

Performance index (PI)

The recorded Performance Index (PI) for the machine stands at 1145.86, serving as a performance parameter that characterizes the implement's role as a weeder. The Performance Index in the context of weeding implements is directly linked to field capacity and weeding efficiency, while being inversely related to the exerted power (Weerasooriya et al., 2017). Notably, the percentage of plant damage was registered as zero, indicating no significant harm to the main crop during weeding activities around coconut trees.

In a study by Nkakini and Husseni (2015), designed a wheeled long-handle weeder and reported a PI of 1108.48, aligning more closely with the findings of the recent study.

Fertilizer Distribution uniformity

The implement operated at its optimal speed, and the uniformity of fertilizer distribution was assessed by measuring the amount released in each quarter of the manure cycle. The obtained data indicates that approximately 25% of the fertilizer was released for each quarter, as depicted in Fig. 9. In summary, the mechanical method exhibited a remarkable fertilizer spreading uniformity of 99.98% when operating at the optimum speed of 1.45 km h^{-1}. In comparison, Mandal and Thakur (2010) study on a subsoiler-cum-differential rate fertilizer applicator revealed uniformity levels for all application rates exceeding 90%, ranging from 93.7% to 98.8%. This significantly surpasses the uniformity observed in the current study.

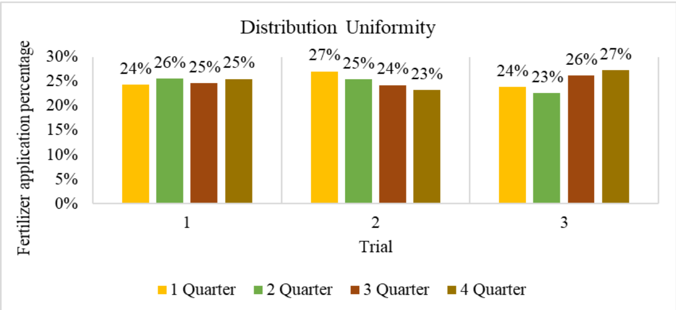


Figure 9. Released amount of fertilizer for each quadrant of the manure cycle.

The average fertilizer placement depth is recorded as 2.5-3.5 cm (1-1 ½ inches).

Economic performance evaluation for coconut weeder cum fertilizer applicator:

Cost of operation for mechanical method

Table 2. *Costs of the implement for fertilizer application*

Case	Cost (Rs)
Production cost (LKR)	88, 500
Machine life (year)	7
Annual Use (hours)	300
Salvage value (LKR)	8,850
Fixed costs	
Depreciation (LKR yr^{-1})	11,378
Repair and maintenance (LKR yr^{-1})	7,080
Total fixed cost (LKR yr^{-1})	18,458
Variable costs	
Labour (LKR h^{-1})	250
Fuel (LKR h^{-1})	271.21
Oil (LKR h^{-1})	27.12
Total variable cost (LKR h^{-1})	548.33
Effective field capacity (ha h^{-1})	0.172
Total cost (LKR/ha^{-1})	3545.7

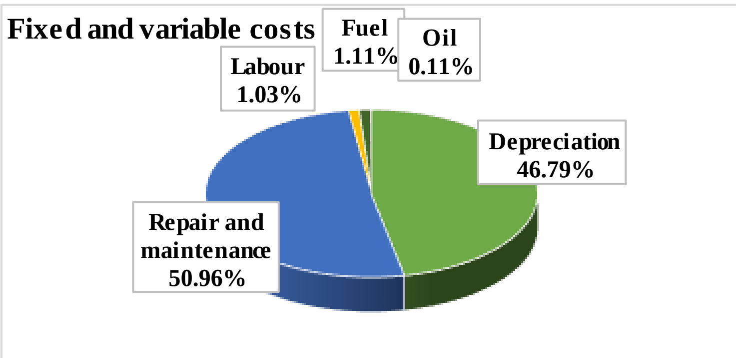
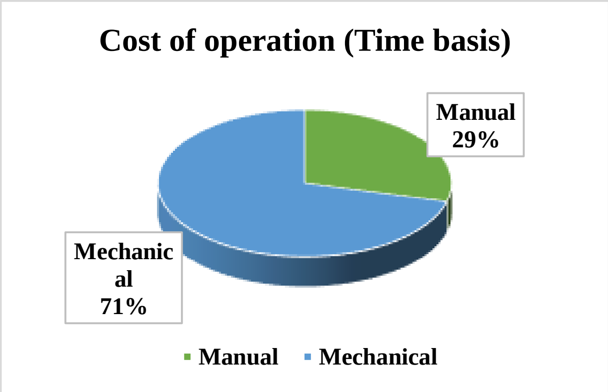
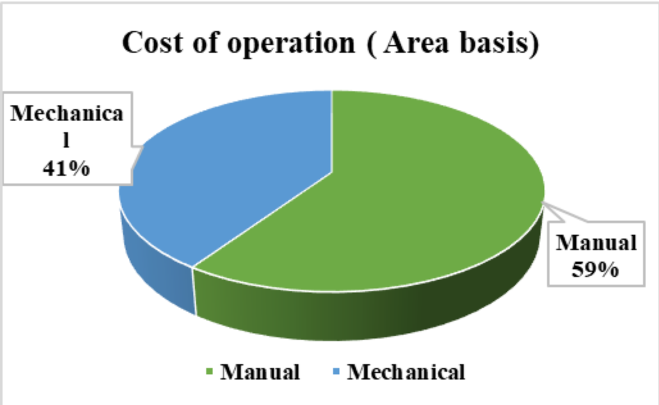


Figure 10. Cost component associate with mechanical method

Cost comparison between manual and mechanical method



(a)



(b)

Figure 11. Cost comparison of manual and mechanical method (a) time basis (b) area basis

Table 2. distinctly outlines the diverse cost components linked to machine performance. The production cost of 88,500 LKR and a machine life of 7 years set the economic foundation for operating the machinery. The total fixed cost for the implement for fertilizer application stands at 18,458 LKR per year, reflecting the ongoing expenses required to maintain the machinery's functionality. Fixed cost encompasses various components such as depreciation and repair costs.

Additionally, the total variable cost amount is 548.33 LKR per hour, representing expenses that fluctuate based on usage, including labor, fuel, and oil costs. These variable costs are directly tied to the amount of work done by the machinery.

Ultimately, the total cost per hectare, amounting to 3,545.7 LKR, encapsulates the cumulative expenses associated with operating the machinery for agricultural production. These values provide valuable insights into the financial considerations and efficiency metrics crucial for decision-making in agricultural operations. Furthermore, Fig.10 distinctly illustrates the separate contributions of fixed and variable cost components, along with the clear percentage representation of each cost element.

Fig. 11(a) illustrates the operational costs for manual and mechanical methods in relation to time. The data reveals that, in terms of time-based costs, the manual method outperforms the mechanical method. Besides, Fig. 11(b) illustrates that the mechanical method boasts lower operational costs compared to the manual approach on an area basis. This substantiates the cost-effectiveness of utilizing the coconut weeder cum fertilizer applicator for mechanical fertilizer application and weeding over manual operations in relation to the area basis.

Break-even point

With a calculated break-even point of 2.85 ha yr^{-1}, the coconut weeder cum fertilizer applicator could be recommended for small and medium scale coconut plantation.

4. Conclusions

The evaluation outcomes affirm the success of the coconut weeder cum fertilizer applicator in accomplishing the study's goals. Notably, the effective field capacity, field efficiency, and weeding efficiency exceeded those of the manual method by 3.58 times, 1.12 times, and 1.1 times, respectively. Besides, Effective Fertilizer Application Rate (EFR) of the machine exhibited 1.7 kg/min. From an economic perspective, the coconut weeder cum fertilizer applicator showcases a cost-saving advantage of around 32% on an area basis compared to manual applications. In summary, the coconut weeder cum fertilizer applicator's overall performance surpasses that of manual methods. Moreover, the machine's single-operator usability and straightforward mechanism make it accessible even for unskilled individuals. These attributes position the coconut weeder cum fertilizer applicator as a promising replacement for existing manual fertilizer application methods in medium and small-scale coconut cultivations in Sri Lanka and other coconut-growing regions, particularly considering its break-even point at 2.85 ha yr^{-1}.

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