



RESEARCH ARTICLE

Efficacy evaluation of two-row paddy power weeder and brush cutter attached rotor with manual rotary weeder for paddy cultivation in Thiruvananthapuram district

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Abstract

Paddy farmers in Thiruvananthapuram district predominantly rely on manual weeding for weed management in paddy fields. The commonly observed weed flora in the region includes *Digitaria ciliaris* (Retz.) Koeler, *Cyperus difformis* L., *Eleocharis* spp. and *Monochoria vaginalis* (Burm.f.) C.Presl ex Kunth, the efficacy of mechanical weeding for *Eichhornia crassipes* (Mart.) Solms is critically dependent on the total extraction of all plant tissues, as incomplete removal triggers rapid clonal expansion through vegetative propagation. To evaluate the effectiveness of different weeding methods, Krishi Vigyan Kendra (KVK) conducted field trials at 30 days after transplanting (30 DAT) over a 1.5 ha paddy field at Varkala, a suburb of Thiruvananthapuram district, Kerala. The treatments comprised the manual paddy finger-type rotary weeder (T1- Technology option 1), brush cutter-attached rotor (STIHL) (T2- Technology option 2) and two-row paddy power weeder (TNAU model- Tamil Nadu Agricultural University) (T3 - Technology option 3). Mechanised transplanting was adopted with a spacing of 21 cm between plants and 30 cm between rows to facilitate efficient operation of mechanical weeders between crop rows. The 21 × 30 cm spacing used with the Kubota transplanter is optimal because the 30 cm row width exactly matches the mechanical weeder's rotors, preventing crop damage and facilitating efficient inter-row weeding. Among the tested implements, the brush cutter was found to be cumbersome, as it had to be carried on the operator's shoulders, making its operation difficult under puddled field conditions. In contrast, the two-row paddy power weeder (T3) exhibited superior performance, recording a field capacity of 0.067 ha hr⁻¹, weeding efficiency of 81.5 % and field efficiency of 95.71 %. The implement (two-row paddy power weeder powered by a four-stroke engine) at 0.55 L hr⁻¹ also demonstrated lower fuel consumption (0.55 L hr⁻¹) and reduced labour requirement (15 man-hr ha⁻¹), while causing minimal crop damage (2 %). The grain yield obtained was 79.24 q ha⁻¹, with a benefit-cost ratio of 2.12. Overall, the two-row paddy power weeder proved to be highly effective in covering larger areas with minimal inputs, leading to significant improvements in productivity and farmers' income.

Keywords: benefit-cost ratio; effective field capacity; field efficiency; paddy power weeder; weeding efficiency

Introduction

Paddy farmers in Thiruvananthapuram district generally practice manual weeding for weed control, using hand tools with long handles or other implements to physically cut, chop, or uproot weeds from the soil. This method is highly labour-intensive, time-consuming and physically demanding (1). To reduce the drudgery associated with manual weeding, small-scale implements such as manual finger-type rotary weeders are also being used by farmers (2); these tools can reduce labour requirements by 40–60 % and lower weeding costs by approximately 30–50 % compared to traditional hand weeding (1, 2).

In this context, KVK conducted a field assessment of a two-row paddy power weeder and a brush cutter-attached rotor in comparison with a manual finger-type rotary weeder in Thiruvananthapuram district at Chemmaruthy Grama Panchayat, Panayara Padashekharam. The assessment was carried out over a farm area of 1.5 ha at 30 DAT. A Kubota walk-behind type rice

transplanter (six-row) was used for mechanised transplanting, maintaining a spacing of 21 cm between plants and 30 cm between rows, which facilitated smooth operation of mechanical weeders between crop rows (3).

The present study aimed to assess the field performance of different weeding technologies in wetland paddy cultivation. The evaluation focused on key operational parameters such as field capacity, weeding efficiency, plant damage, labour requirement and operational cost. Field capacity was determined through effective area-to-time ratios, weeding efficiency via pre- and post-operational weed biomass sampling and plant damage by measuring the percentage of mechanically injured seedlings relative to the total stand. In addition, the study analysed yield response and benefit-cost ratio (BCR) of each technology and documented farmers' perceptions and usability feedback to understand the practicality and acceptability of the implements under field conditions.

The cost of paddy cultivation in Kerala is considerably higher than that of many other agricultural crops. Concurrently, the area under paddy cultivation in the state has declined drastically, from 8.82 lakh ha in 1974–1975 to only 1.17 lakh ha by 2023–2024. The decline in Kerala's paddy cultivation is fundamentally caused by a shift to profitable cash crops (rubber, coconut) and urbanisation, exacerbated by high labour costs and climate stress. These factors collectively make traditional rice farming economically unviable, leading to extensive land abandonment and a significant food production deficit. Although Kerala's average paddy productivity (3108 kg ha⁻¹) exceeds the national average of 2800 kg ha⁻¹, it still remains below its potential productivity levels (4). Table 1 shows the seasonal labour cost as a percentage of total

Table 1. Seasonal labour cost as a percentage of total input costs

Season	Labour cost (Total input cost (%))
Autumn (Virippu)	54.93
Winter (Mundakan)	55.98
Summer (Puncha)	48.61

input costs (5).

Mechanical weeders offer a practical solution for reducing labour requirement, drudgery and weeding costs in paddy cultivation. Studies have reported weeding efficiencies of up to 85 % with mechanical weeders, comparable to or better than manual weeding, while significantly reducing labour input (6). Power weeders demonstrated higher field efficiencies compared to rotary weeders. Power weeders achieved 78 % efficiency at DAS and 80 % at 45 DAS, while rotary weeders recorded efficiencies of 66.20 and 65 % at the same stages, respectively (7). The TNAU power weeder has been reported as simple to operate, efficient and cost-effective, resulting in savings of up to 60 % in labour, time and cost (7).

In pulse crops, mechanised power weeding has been found highly economical, with different models reducing weeding costs by 54.8–75.8 % compared to manual weeding (8). In SRI cultivation, wider spacing (25 × 25 cm) combined with mechanical weeders such as cono and rotary weeders significantly increased yield (555 kg ha⁻¹) compared to farmers' practice (275 kg ha⁻¹), with cono and rotary weeders performing well under wet conditions (9). The KAU-developed self-propelled cono weeders have achieved a field capacity of 0.1 ha hr⁻¹ and weeding efficiency comparable to manual cono weeders operated at 15 and 30 DAT (10).

Studies from Patna revealed that integrating herbicide application with mechanical weeding did not improve weed control efficiency or grain yield compared to mechanical weeding alone, with cono weeder operation twice or thrice achieving weed control efficiencies above 90 % (11). Mechanical rice weeders attached to narrow steel-wheeled tractors have demonstrated increasing weeding efficiency with crop age, reaching up to 86.03 % at 60 DAT (12). Modified self-propelled weeders have shown fuel efficiency ranging from 0.63–0.70 L hr⁻¹, with weeding efficiencies of 74.20 and 85.90 % at 20 and 45 DAS, respectively (13). Similarly, the J-shaped dry power weeder developed by NRRI recorded a field capacity of 0.0257 ha hr⁻¹, weeding efficiency of 61.53 %, zero plant damage and a labour requirement of 38.91 man-hr ha⁻¹, proving superior to traditional weed control methods in terms of cost and labour savings (14).

Across India, a wide range of paddy weeders are used under both dry and wet conditions, with the two-row power-operated rotary weeder emerging as one of the most efficient options, offering a field capacity of 0.0793 ha hr⁻¹, a weeding efficiency of 79.92 % and a cost of ₹1169.59 ha⁻¹. However, most existing weeders are limited to inter-row operations, indicating the need for improved inter-cum-intra-row weeding technologies to enhance efficiency and crop yield (15).

In view of the above considerations, the present study evaluated the performance of the manual paddy finger-type rotary weeder (T1), brush cutter-attached rotor (STIHL) (T2) and two-row paddy power weeder (TNAU model) (T3) to address labour scarcity and improve weeding efficiency in wetland paddy cultivation.

Materials and Methods

The field experimental evaluation was conducted at Panayara Padashekharam, Chemmaruthy Grama Panchayat, Varkala Block, Thiruvananthapuram district, Kerala. The rice variety Uma was transplanted using a Kubota walk-behind rice transplanter (six-row model), maintaining a spacing of 21 cm between plants and 30 cm between rows. The dominant weed flora observed in the experimental field included *Digitaria ciliaris* (Retz.) Koeler, *Cyperus difformis* L., *Eleocharis* spp. and *Monochoria vaginalis* (Burm.f.) C.Presl ex Kunth. Mechanised transplanting, such as using a Kubota six-row model, ensures a highly consistent crop stand with uniform hill and row spacing. This uniformity minimises random gaps where weeds could flourish disproportionately.

To address labour scarcity in paddy weeding, three weeding implements were evaluated: The manual finger-type rotary weeder (T1), the brush cutter-mounted rotor (STIHL) (T2) and the two-row paddy power weeder (TNAU model) (T3). The manual wetland finger weeder, designed with serrated or smooth blades and flexible fingers, is suitable for operation within narrow row spacing of 20–25 cm commonly adopted in paddy cultivation. The brush cutter-attached rotor consists of V-shaped blades with a working width of 15 cm, enabling effective uprooting of young weeds under waterlogged field conditions. The unit is powered by a two-stroke, 1.8 hp petrol engine brush cutter and is suitable for operation in approximately 25 cm row spacing. The power weeder is equipped with a four-stroke, 1 hp petrol engine and durable hatchet- or curved L-shaped blades and is designed for efficient cultivation within narrow inter-row spacing of about 15 cm.

A comparative field evaluation was conducted at 30 DAT over an area of 1.5 ha. The performance parameters assessed included weeding efficiency, field efficiency, field capacity, fuel

Table 2. Technical specifications of the mechanical weeders

Weeding implement	Technical specifications
T1- Manual paddy finger-type rotary weeder	Manually operated
T2- Brush cutter attached rotor (STIHL)	2-stroke petrol engine (1.8 hp); row spacing 25 cm
T3- Power weeder (TNAU)	4-stroke petrol engine (1 hp); row spacing 15 cm

consumption, labour requirement, plant damage, cost of operation, grain yield and BCR. The technical specifications and constructional details of the implements evaluated are presented in Table 2.

Parameters to be observed

The following machine parameters were observed during the testing. Farmers and rural youth trained by KVK operated the equipment in the field to complete the weeding operation in the entire padashekharam (paddy field).

Actual field capacity (ha hr^{-1})

$$= (\text{Total area covered (ha)})/(\text{Total time taken (hr)})$$

$$C = A/T \quad (\text{Eqn.1}) \quad (16, 17)$$

Theoretical field capacity (ha hr^{-1}) = (Speed (km hr^{-1}) $\times$ Width of implement (m))/10

$$\text{TFC} = (\text{Width} \times \text{Speed})/10 \quad (\text{Eqn. 2}) \quad (18)$$

Field efficiency (%) = (Actual field capacity)/(Theoretical field capacity) $\times$ 100
(Eqn. 3) (19)

Weeding efficiency (%) = (Weeds removed/Total weeds before weeding) $\times$ 100
(Eqn. 4) (20)

Plant damage (%): It is mechanical damage to the plants by the implement during operation due to abrasion, cut, etc. It was calculated as:

Plant damage (%) = (Number of damaged plants per unit area)/(Total number of plants per unit area) $\times$ 100
(Eqn. 5) (21)

Fuel consumption (L hr^{-1}) = (Fuel consumed per plot in litre)/(Time consumed in hour)
(Eqn. 6) (22)

Yield and BCR: Standard economic analysis
(Eqn. 7)

Cost of operation

The cost of operation was computed by accounting for depreciation, interest on capital, housing, repair and maintenance, fuel consumption and operator wages for the power weeder, whereas for the wheel hoe, star weeder and traditional local hand tools, only operator wages were considered.

Results and Discussion

Weeds can reduce paddy yield by 40–65 %, making their effective management a major challenge for farmers. Conventional weed control methods such as hand weeding, chemical herbicide application and the use of simple mechanical weeders each have inherent limitations. Hand weeding is labour-intensive and time-consuming; herbicide use raises concerns related to environmental safety and human health and many mechanical weeders fail to achieve the desired level of efficiency under field conditions (16).

In the present study, three weeding technologies-manual finger-type rotary weeder (T1) (Plate 1), brush cutter-mounted Rotor (T2) (Plate 2) and two-row paddy power weeder (T3) (Plate

3) were evaluated and their performance results are presented below. Machine performance parameters and economic analysis constituted the two major components for assessment, with the consolidated results of all three implements presented in Table 3. The operational performance and field functioning of the weeders are illustrated in Plate 4–7.

Machine parameters

Field capacity

The manual finger-type weeder (T1) recorded the lowest field capacity, covering an area of $0.0096 \text{ ha hr}^{-1}$, followed by the brush cutter-mounted rotor (T2) with a field capacity of 0.050 ha hr^{-1} . The two-row paddy power weeder (T3) achieved the highest field capacity of 0.067 ha hr^{-1} . Although the engine power of the two-row paddy power weeder (1 hp) was lower than that of the brush cutter (1.6 hp), the latter was found to be cumbersome to operate under puddled field conditions, as the operator had to carry the unit on the shoulder while moving through the field. Moreover, the absence of a mud guard in the brush cutter-mounted rotor resulted in excessive splashing of clay over the operator and field, leading to uneven and uncomfortable operation despite the higher engine power.



Plate1. Manual paddy finger type rotary weeder (T1).



Plate 2. Brush cutter attached rotor (STIHL) (T2).

Table 3. Weeding performance of different weeding technologies

Parameters	T1	T2	T3
Field capacity (ha hr^{-1})	0.0096	0.050	0.067
Weeding efficiency (%)	79	70	81.50
Field efficiency (%)	16	74.63	95.71
Plant damage (%)	1	9	2
Fuel consumption (L hr^{-1})	Nil	0.65	0.55
Labour requirement (man-hr ha^{-1})	105	20	15
Cost of operation (₹ ha^{-1})	16800	5000	3750
Yield (q ha^{-1})	54.95	62.43	79.24
BCR	1.42	1.85	2.12



Plate 3. Power weeder (T3).

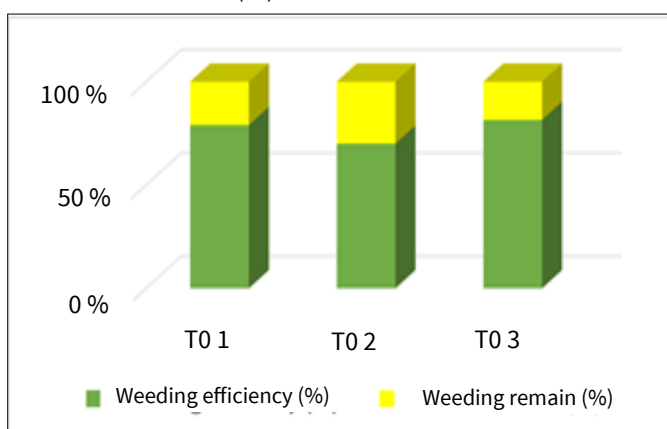


Plate 4. Weeding efficiencies of different weeding technologies.



Plate 5. Working of manual paddy finger type rotary weeder.



Plate 6. Working of brush cutter attached rotor (STIHL).



Plate 7. Working of power weeder.

In contrast, the two-row paddy power weeder (T3), though equipped with a lower-powered engine, is self-propelled, which facilitates easier manoeuvrability and smoother movement in puddled soils. This design advantage enabled the implement to cover a larger area within a given time, thereby resulting in superior field capacity.

Weeding efficiency

Weeding efficiency was influenced by blade geometry, engine power and the type of equipment used. In treatment T2, the rotor was fitted with V-shaped blades having a working width of 15 cm, which enabled effective uprooting of weeds within the 30 cm intra-row spacing through the brush cutter attachment. The reduced efficiency of the brush cutter attachment (T2) is fundamentally a result of mechanical impedance and operator-induced variability. The gearbox design, optimised for high-velocity grass trimming rather than high-torque soil penetration, leads to inconsistent blade rotation in compacted soils. Furthermore, the lack of self-propulsion requires the user to manually support the 7–10 kg engine weight while executing a swinging motion, leading to rapid physiological fatigue and a subsequent loss of operational precision that diminishes weeding efficacy relative to specialised power units.

In treatment T3, curved L-shaped blades of 15 cm width were mounted on the rotary wheel, facilitating effective soil stirring and weed uprooting in puddled conditions.

The manual finger-type rotary weeder (T1) recorded a weeding efficiency of 79.0 %, indicating its effectiveness under wetland conditions. The brush cutter-mounted rotor (T2) achieved a comparatively lower weeding efficiency of 71.0 %, whereas the two-row paddy power weeder (T3) registered the highest weeding efficiency of 81.5 %. Overall, the power weeder demonstrated superior weed control efficiency compared to manual and brush cutter-based implements.



Plate 8. Before weeding.



Plate 9. After weeding.

The comparative performance of field parameters for power weeders under dryland and wetland conditions is illustrated in Plate 8 and 9. The observed weeding efficiency of the power weeder was comparable with that of the Ambika weeder, which recorded efficiencies of 74.22 and 86.0 % at 20 and 45 days after sowing (DAS), respectively (16). Similar findings were also reported, wherein power weeders achieved a maximum weeding efficiency of 85.13 % (23).

Field efficiency

Field efficiency was highest in treatment T3 (95.71 %), followed by T2 (74.63 %), while the lowest field efficiency was recorded in T1 (16.0 %). The superior field efficiency observed with the two-row paddy power weeder may be attributed to its self-propelled design and effective blade-soil interaction under puddled field conditions. Similar trends have been reported earlier, wherein power weeders recorded higher field efficiency values of 78 % at 20 DAS and 80 % at 45 DAS, compared to the manually operated rotary weeder, which registered lower efficiencies of 66.20 and 65 %, respectively, during the same periods (7).

Plant damage

Plant damage was quantified by counting the number of rice plants in a fixed sampling area (such as a 1 × 1 m quadrat or a specific row length) both before and after the weeding operation. The final values, such as the 9 % recorded for (T2), represent the average percentage of injured or uprooted plants across three replications. This standardised counting method ensures a precise measurement of mechanical impact rather than a subjective visual estimate. Machine power and operational speed had a noticeable influence on crop damage. In the present study, plant damage was highest in T2 (9 %), followed by T3 (2 %) and T1 (1 %). The greater crop damage observed in the brush cutter-mounted rotor (T2) may be attributed to the aggressive rotor action and higher operational speed, which increased the likelihood of contact with rice plants. In contrast, the manual finger-type rotary weeder (T1) caused minimal plant damage due to controlled manual operation.

Similar observations have been reported earlier, where plant damage was highest in power weeder treatments (4.23 %) owing to higher speed of operation, while the lowest damage was recorded under hand weeding (0.36 %). However, despite lower crop damage, hand weeding was found to be more labour-intensive and time-consuming compared to mechanical weeders (23).

Fuel consumption

The brush cutter equipped with a two-stroke engine recorded a fuel consumption rate of 0.65 L hr⁻¹, whereas the two-row paddy power weeder powered by a 4-stroke engine consumed comparatively less fuel, at 0.55 L hr⁻¹.

Economic analysis

Labour requirement, cost of operation, grain yield and BCR were the major parameters evaluated under this category. Among the treatments, T3 required the least labour input (15 man-hr ha⁻¹) and recorded the highest grain yield (79.24 q ha⁻¹) along with the maximum BCR (2.12). In contrast, T1 was the slowest operation and proved to be the least economical. Overall, mechanised weeders performed better than manual weeding in terms of operational efficiency and crop response. The two-row paddy power weeder

exhibited superior efficiency and yield performance, whereas the manual weeding tool was constrained by a low work rate. Mechanisation resulted in substantial labour savings of about 85 % and contributed to improved crop performance.

Similar trends have been reported earlier, wherein the cost of weeding operations was reduced by 18.9, 60.2 and 67.8 % with the use of rotary weeder, cono weeder and power weeder, respectively, compared to the control (hand weeding) method (23).

Conclusion

It could be concluded from the results that the two-row paddy power weeder (T3) exhibited superior field performance, recording higher field capacity, field efficiency and weeding efficiency, while requiring the least labour input and lowest operational cost. Its higher operational efficiency resulted in the maximum grain yield of 79.24 q ha⁻¹ and the highest benefit-cost ratio (2.12). Although the brush cutter-mounted rotor (T2) was faster than manual weeding, it caused greater crop damage, whereas the manual finger-type weeder (T1) remained slow, labour-intensive and uneconomical under wetland conditions. Farmer feedback confirmed that power weeders significantly reduced weeding time and labour costs while improving yield levels. Overall, mechanised weeding resulted in 77.68 % savings in operational costs, a 44.22 % increase in yield and a 49.30 % increase in profit, indicating strong potential for enhancing farmers' income under labour-scarce wetland paddy systems. The two-row power weeder (T3) remains the superior choice for wetland paddy due to its optimal balance of operational efficiency and economic sustainability. While the brush cutter (T2) offers speed, it is hindered by mechanical torque limitations and high ergonomic demand, leading to excessive plant damage. Conversely, manual methods (T1) are incompatible with modern agricultural requirements due to their excessive time and labour costs. Future research should prioritise AI-driven precision sensing to eliminate plant damage, the development of high-torque battery-electric weeders for carbon reduction and the integration of autonomous platforms to fully remove manual drudgery from labour-scarce farming systems.

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Authors' contributions

CG conceived the study, designed the experimental layout and supervised the field evaluation. CG and ABC conducted the field experiments, collected data on machine performance and agronomic parameters and prepared the initial draft of the manuscript. CG contributed to data interpretation, critically reviewed the manuscript and made necessary revisions. Both authors read and approved the final manuscript.

Compliance with ethical standards

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

Ethical issues: None

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