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Economic Evaluation of Developed Walking Type Multi-Crop Power Weeder

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ABSTRACT

Weeding is a labor-intensive task in agriculture, constituting a significant portion of cultivation expenses. Manual weeding demands substantial labor and suffers from drawbacks such as discomfort and time consumption. Chemical weeding, though costly, can damage the soil quality and increases the cost of cultivation. Addressing small and marginal land holdings prevalent in India, rotary power weeders offer an economical alternative. A walking-type multi-crop power weeder was developed to address variable crop row spacing and an economic viability study was conducted for the developed machine. The performance parameters such as actual field capacity, payback period, break-even point and the total cost of operation of walking type multi-crop power weeder were calculated as 0.03 ha/h, 0.41 years, 53.2 h/year and Rs.193 per hour respectively. In terms of operational efficiency and cost savings, the developed weeder outperforms manual weeding.

Key words: *Weeding, Power weeder, Cost economics, Payback period and break-even point*

Introduction

Agriculture plays an integral role in the economy of India and the total workforce involved in agriculture and allied sector in the country is 54.6%. Weeding stands as a pivotal agricultural task, known for its demanding labor requirements. Notably, a substantial portion i.e., one-third of cultivation expenses is incurred to manual weeding. This labor-intensive process commands a significant workforce, accounting for approximately 25% of the overall labor demand, equivalent to 900-1200 man-hours per hectare (Srinivas *et al.*, 2023). In India, manual labor remains the dominant approach for weeding, often involving the use of traditional hand tools such as khurpi or trench hoes. This practice, however, comes with drawbacks, including the discomfort and back pain experienced by laborers due to the required bending posture. Furthermore, manual weeding is both labor-intensive and time-consuming. While chemical weeding is gradually gaining traction despite its high cost, it is important to note that herbicide use can lead to lingering effects on soil composition and a decrease in soil quality.

Around 88% of the operational holdings of agriculture in the country are small and marginal. The percentage of small and marginal land holdings is 58.39% of total land holdings in Rajasthan for the year 2020-21 (Anonymous, 2021). Rotary power weeders are specifically developed to cater to this

([*1,4]Assistant Prof., [2]Subject Matter Specialist, [3]Ph.D Scholar, [5]Associate Prof. and Head) demographic, offering an economical alternative in comparison to other weed management approaches. The rising interest in mechanical inter-row weeders can be attributed to concerns surrounding diminishing labor availability, environmental degradation, and the increasing demand for organic food.

The advancement of technical mechanisms for weed control using inter-row weeders holds promise in meeting both consumer and environmental requirements. This progress significantly contributes to the safer production of food for the population. The precision of the rotary power weeder's operation lies in its ability to stir the soil, target weed roots, and displace them from the earth (Srinivas and Meena, 2020). Moreover, this process aids in maintaining soil looseness, promoting proper aeration. A key advantage of the power weeder lies in its efficient utilization of power for blade operation, resulting in reduced draft and enhanced field performance. The cost of weeding by engine operated weeder is about one-third of weeding by manual labour.

Currently, power weeders are designed exclusively for specific fixed row crop spacing, lacking the capability to adjust the working width of machine according to varying spacing between rows in different crops. The need arises to create a proficient power weeder that addresses variable crop row spacing, aiming to achieve increased weeding efficiency while minimizing damage to plants. Considering these aspects, a walking-type multi-crop power weeder was developed. This design incorporates attachable shafts to support the cutting blades, coupled with a suitable power transmission mechanism. This innovative approach enables the weeding operation to be executed across different crops with varying row spacing. Subsequently, an economic assessment of the walking-type multi-crop power weeder was undertaken to evaluate its practical viability in field applications.

Materials and Methods

The performance evaluation of the developed walking-type multi-crop power weeder was accomplished at Rajasthan College of Agriculture (RCA), Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipurr. Detailed specifications of the walking-type multi-crop power weeder are presented in Table 1. The components of this weeder comprise the engine, worm gearbox, cutting blades, flanges, and other elements. The total expenditure for the development of this weeder amounted to Rs.24,200/-.

Performance Evaluation of machine

The performance evaluation of the developed weeder was conducted in vegetable crops. Prior to the evaluation, a preliminary operation of the machine was carried out within each crop to confirm its effective functioning. Specifically, the machine testing focused on vegetable crops such as chilli and okra crops, both featuring a 250 mm working width of the machine. These crops were selected with consideration of their row-to-row spacing of 300 mm. The experimentation was conducted for three replications, each employing six cutting blades per set of flanges, across the designated crops.

Economic evaluation of machine

The cost assessment of the weeding operation included all relevant factors, including prevailing in-

Table 1. Specifications of walking type multi-crop power weeder

S.No	Particulars	Specifications
1	Number of engine cylinder	1
2	Engine maximum power at 3600 rpm	1.8 kW
3	Working width	150, 250, 350 & 450 mm
4	Working depth	40 to 50 mm
5	No. of blades per flange	6
6	Rotor speed	200 rpm
7	Power transmission	Worm gear reduction box
8	Fuel tank capacity	1.1 litre
9	Fuel type	Petrol with lubrication oil in 25:1 ratio
10	Type of cutting blade	'L' shape
11	Total weight	21.8 kg

put and fabrication expenses for the weeder, labour charge, fuel expenditures, and more. The weeding operationwere done in chilli and okra crops, specifically at 30, 45 and 60 days after sowing (DAS). The annual usage of the walking-type multi-crop power weeder was assumed as 500 hours. The total operational cost of the weeder was calculated on an hourly basis, considering both fixed and variable costs.

The fixed cost category as detailed in Table 2 includes depreciation, capital cost, interest, insurance, taxes, and housing expenses. Meanwhile, the variable cost category as outlined in Table 3 includes elements such as fuel consumption, lubrication, repair and maintenance, and operator wages. The total cost, which combines fixed and variable costs, was then converted into an area basis by multiplying with effective field capacity of machine and it was expressed in terms of rupees per hectare.

To determine the payback period and break-even point (BEP) in terms of area and time, standard cost estimation methods were employed. The economic evaluation of the weeder adhered to the straight-line method of cost estimation, maintaining accuracy and consistency throughout the economic evaluation.

Annual utility

Annual utility refers to the yearly average utilization of a farm implement ormachinery. This parameter is influenced by the number of available working days dedicated to a specific operation involving the machine throughout the year. In the case of walking-type multi-crop power weeder, its annual utility was assumed as 500 hours.

Break-Even Point

The break-even analysis is employed to determine the duration of work at a given price necessary to cover all costs and expenses, resulting in neither profit nor loss (Monalisha and Goel, 2017). The break-even point occurs where the total cost line intersects the custom hiring cost line. If the break-even point value is lower than the weeder's annual utility, it becomes advantageous for the farmer to own the machine. Conversely, if the break-even point value exceeds the weeder's annual utility, purchasing the machine might lead to a loss for the farmer. Thus, in such circumstances, opting for custom hiring of the machine emerges as the optimal choice. The calculation of the break-even point is determined by the following equation.

$$BEP = \frac{AFC}{CF - V}$$

where,

BEP = Break-Even point, h/year

AFC = Annual fixed cost for the machine, Rs./year

CF = Custom fee, Rs./h

V = Variable cost of machine, Rs./h

Payback period

The payback period signifies the duration in years

Table 2. Formulas for calculation of fixed cost

Depreciation per year (Hegazy *et al.*, 2014)	$\frac{C - S}{L \times H}$	1. Expected life of weeder = 10 years 2. Working hours (H) = 500 h/year, Working hours (h) = 8 h/day
Interest per year (Kankal, 2013)	$\frac{C + S}{2} \times \frac{i}{H}$	3. Salvage value (S) = 10% of capital cost
	$C \times \frac{Y}{100}$	4. Rate of interest (i) = 10% per annual 5. Y= 2% of capital cost

Table 3. Formulas for calculation of variable cost

Fuel cost (Rs./h)	Fuel consumption(l/h) × Fuel cost (Rs./l)	Where,
Lubrication cost (Rs./h)	5% of Fuel cost (Rs./h)	C=Capital cost H=Annual working hours
Repair and maintenance (Rs./h)	$\frac{C}{H} \times \frac{R}{100}$	R= 5% of Capital cost Fuel consumption = 0.71 l/h
Wages of operator, (Rs./h)	Rs. 800/- per day for 8 hours	Fuel cost =Rs.110 per litre

that an investment requires to recuperate its initial cost through the annual cash revenues it generates, under the assumption of consistent net cash revenues each year. The payback period was computed using the equation provided by Singh *et al.*, 2016.

$$\text{Payback period} = \frac{C}{B}$$

Where,

C = Initial investment = Rs.24,200

B = Average net annual benefit = (CF-V) × Annual usage of the machine

CF = Custom fee= (Cost of operation (Rs./h)+ 25% overhead charges) × (25% profitover new cost)

V= Variable cost of machine, Rs./h

Results and Discussion

Performance evaluation of developed machine

The effectiveness of weeder was assessed employing the configuration of six blades per flange. The design of weeder was oriented towards accommodating two distinct variable working widths, rendering it adaptable across diverse crops, serving the role of a multi-crop power weeder. The trial of the 250 mm working width arrangement was conducted within vegetable crops, with row-to-row spacing set at 300 mm. The field capacity of the developed weeder was calculated following standard procedure. Notably, the field efficiency obtained from the configuration of six blades per flange yielded a higher performance in the case of okra crops (82.5%) compared to chilli crops (80.7%).

Cost Economics of developed machine

Life and annual utility of machine were considered as 10 years and 500 hours per year respectively.The operational expenses associated with weeding, utilizing the 250 mm working width configuration of the machine, were computed as Rs. 3800/- per hectare for okra crop and Rs. 3950/- per hectare for chilli crop.

Cost of ooperation of developed machine

Capital cost

The determination of the capital cost of weeder involved assessing both the aggregate value of materials utilized in its construction and the corresponding fabrication expenses. The capital cost of weeder is Rs. 24,200/-.

a) Fixed cost

1. Depreciation (D) per hour

$$D = \frac{C - S}{L \times H} = \frac{24200 - 2420}{10 \times 500} = \text{Rs.}4.35/\text{h}$$

2.Interest(I) rate per hour

$$I = \frac{C + S}{2} \times \frac{i}{H} = \frac{24200 + 2420}{2} \times \frac{0.10}{500} = \text{Rs.}2.66/\text{h}$$

3. Housing, insurance and tax charges

$$H = \frac{2}{100} \times 24200 = \text{Rs.}484/\text{year} = \text{Rs.}0.96/\text{h}$$

Total fixed cost = 4.35 + 2.66 + 0.96 = Rs.7.97/h C" Rs.8/h

b) Variable cost

1. Fuel cost

Average fuel consumption = 0.71 l/h (Fuel cost = Rs.110/-)

Fuel cost = 110 × 0.71 = Rs.78.1/h

2. Lubrication cost

Lubrication cost = 5% of Fuel cost = $\frac{5}{100} \times 78.1$ = Rs.3.9/h

3. **Repair and maintenance** @5% of capital cost

$$R = \frac{C}{H} \times \frac{R}{100} = \times \quad = \text{Rs.}2.42/\text{h}$$

4. **Labour charge** = Rs.800/day = Rs.100/h

Total variable cost = 78.1 + 3.9 + 2.42 + 100 = Rs.185/h

Total cost of weeding with developed machine (Rs./h)= Fixed cost + Variable cost

= 8 + 185

= Rs.193/h

Total cost of weeding with developed machine (Rs./ha)

Effective field capacity of machine = 0.0302 ha/h

Cost of operation of weeder for Multi Weeder =

$$\frac{\text{Total cost of weeding (Rs./h)}}{\text{Effective field capacity (ha/h)}}$$

$$= \frac{193}{0.0302}$$

= Rs.6391/ha

Break-Even Point

AFC = Total fixed cost (Rs./h) × Working hours (h) = 8 × 500 = Rs.4000/-

Total cost of operation = Total fixed cost + Total variable cost= 8 + 185 = Rs.193/h

Custom fee (CF)= (Cost of operation (Rs.h^{-1})+ 25 % overhead charges) × (25per cent profit over new cost)

= (193 + (193×0.25)) × 1.25

= Rs.302/h

$$BEP = \frac{AFC}{CF-V} = \frac{4000}{302 - 185} = 34.1 \text{ h/year}$$

The Break-Even point of machine is calculated as 34.1 h/year and it is plotted in the graph as shown in Fig. 1.

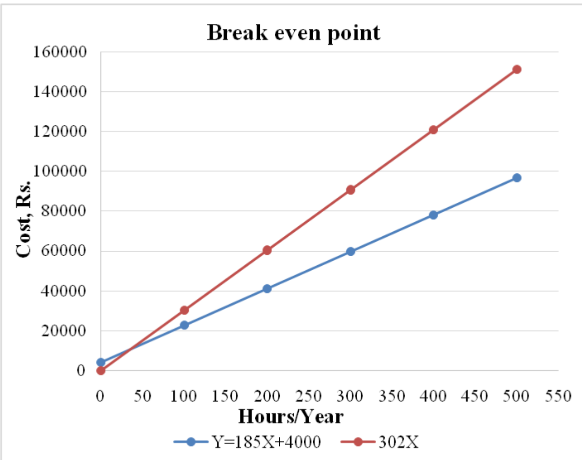

Fig. 1. Break-Even point

Annual Utility

Annual utility = Effective field capacity (ha/h) × Annual utility (h)

= 0.0302 × 500

= 15.1 ha

Thus, BEP can be obtained at (34.1×100)/500 = 6.82% of the annual utility of 500 hours of the developed weeder.

Payback Period

Average net annual benefit (B) = (CF-V) × Annual utility

= (302 - 185) × 500

= Rs.58,500

$$\text{Payback period} = \frac{C}{B} = \frac{24200}{37500} = 0.41 \text{ years}$$

Conclusion

The usage of the walking-type multi-crop power weeder demonstrated profitability in terms of time savings, reduced labor requirements, and efficient operational costs for weeding operation. The operational cost of the developed weeder is Rs.193 per hour. Notably, the actual field capacity, payback period, and break-even point of the weeder were determined to be 0.03 ha/h, 0.41 years, and 34.1 h/year, respectively. The break-even point is reached within a period equivalent to 6.82% of the annual utility of 500 hours. These findings collectively affirm the cost-effectiveness and practical utility of the developed machine for enhancing weeding operations across various crops, offering valuable benefits to farmers.

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