Original Research Article

Economic Analysis and feasibility of Self-Propelled Rotor Power Weeder

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ABSTRACT

The manual weeding process is laborious, requires significant effort, and is a costly operation. Farmers typically allocate 30 to 40 percent of their total crop production expenses to the weeding process. The research was carried out by development and economic feasibility of self-propelled weeder for small category farmers. Economic analysis and feasibility of developed mechanical weeder was evaluated by considering cost of operation, breakeven point and payback period. The utilization of a self-propelled weeder for mechanical weeding can result in cost savings of up to 45% compared to the manual weeding method. The estimated break-even point (BEP), calculated based on time and area, indicates potential savings of 209.6 hours and 13.63 ha. The payback period, assessed on a time basis for the rotary power weeder, was determined to be 1.02 years. The total development cost for the self-propelled power weeder was recorded as 8050 Rupees. By adopting self-propelled power weeder, farmer saving 1856 ₹/ha directly over manual method.

Keywords Self-propelled weeder; Cost of operation; Break-even point; Payback period.

1. INTRODUCTION

Weeding represents a labor-intensive operation in crop production, constituting approximately 25% of the total labor requirement (900-1200 man h/ha) throughout a cultivation season, as reported by (Yadav and Pund, 2007) and (Kumar *et al*., 2014). In Indian agriculture, human farm power availability was documented as 0.091 kW/ha in 2016-17. Over the years, the power availability from draught animals has decreased from 0.221 kW/ha in 1971-72 to 0.130 kW/ha in 2016-17, as highlighted by (Mehta *et al.,* 2019). The collective average farm power availability in India has shown a notable increase, rising from approximately 0.30 kW/ha in 1960-61 to about 2.02 kW/ha in 2013-14, as reported by (Surendra Singh *et al.,* 2014). The wages for agricultural workers and draught animals are on a continual rise, prompting a strong recommendation for a more aggressive adoption of mechanization in the agricultural sector. Weeding operations are typically conducted 2 to 3 times during crop production, varying based on the level of weed infestation and the type of crop. Approximately one-third of the cultivation cost is allocated exclusively to weed control operations. Any procrastination or neglect in the weeding process can result in a significant impact on crop yields, ranging from 30 to 40% (Mohan *et al.,* 2020). Existing weeding methods include manual labor, incurring costs ranging from 3000 to 4000 ₹/ha, depending on the location. Timely completion of weeding is crucial for ensuring proper vegetative crop development and enhancing overall crop productivity.

In the Indian context, agricultural farm holdings are characterized by being small and fragmented. The elevated initial costs and higher capacity of weeders have rendered their usage economically impractical or impossible for small or medium-sized farms (Mishra *et al.,* 2017). Considering above factors, a rotary weeder developed at College of Agricultural Engineering, Madakasira. Rotary weeder was developed and evaluated in chilli, cotton, maize and groundnut crops. Rotary weeder is a machine operated by the 5 hp self-propelled diesel engine, it conducts inter-cultivation between the rows. Timely weeding operations contribute to energy and time savings. (Rawat *et al.,* 2007 and Mynavathi *et al.,* 2015). The main objectives of research are to analyze, total cost of machine and to determine the economic feasibility of the Rotary weeder for small farms.

2. MATERIAL AND METHODS

2.1 Self-propelled rotor power weeder

The rotor weeder is attached to prime mower of 5 hp Honda diesel engine. It was designed and developed at the Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, Acharya N.G. Ranga Agricultural University, Madakasira. Overall dimensions of the machine length × width × height was 2000 × 660 × 1200 mm. The three major components of the developed machine are main frame, weeding assembly and power transmission system. Width of coverage of implement was designed to suitable for both 30 cm and 60 cm row spaced crops by an adjusting the spacing between two rotors. An amount of rupees 8050 were spent for development of the self-propelled rotor power weeder.

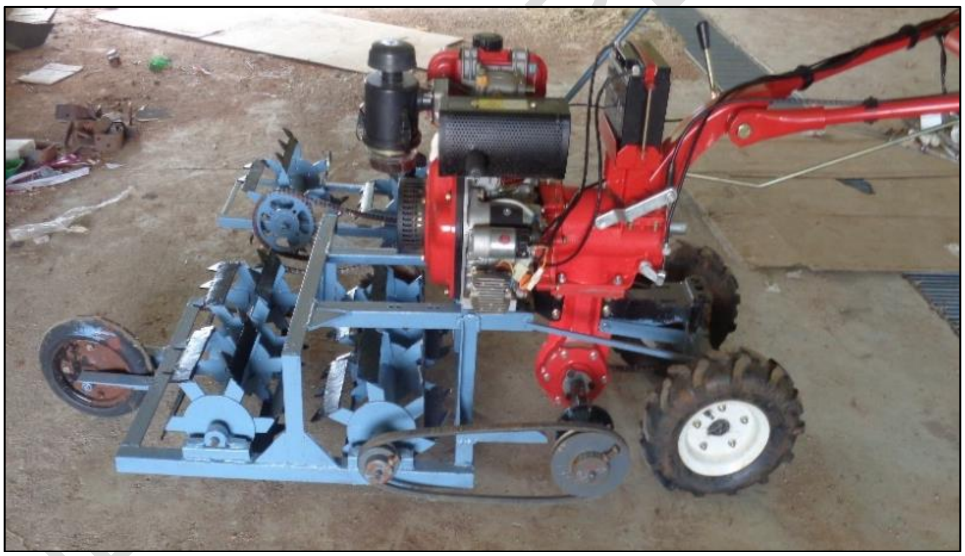

Fig .1 Developed self-propelled rotor power weeder

Table 1. Particulars of the self-propelled rotor power weeder

S. No	Component and Material	Specifications
1.	Flange (Mild steel)	14 cm diameter × 0.5 cm thickness
2.	Blade with pegs (Mild steel)	21 cm length × 0.5 cm thickness
3.	Blade supporter (Mild steel)	10 cm length × 0.5 cm thickness
4.	Galvanized iron pipe	4.8 cm diameter × 21 cm length
5.	Solid square shaft	65 cm length × 19 mm^2 rod

	(Mild steel)	
6.	Hollow square shaft (Mild steel)	25 cm length × 21 mm^2 pipe
7.	Ball bearings (Mild steel)	14 mm inner diameter and 34 mm outer dia.
8.	U-clamp	1 inch
9.	Pulleys (Cast iron)	3 inch diameter
10.		6 inch diameter
11.	V - belt	43 inch length
12.	Hexagonal solid rod (Mild steel)	24 mm diameter × 20 cm length
13.	Front wheels for transportation	Big = 25 mm diameter
14.		Small = 15 mm diameter
15.	Sprockets with chain	14, 20, 30 and 40 tooth, chain of 2 m length
16.	Transportation wheels	Flange = 12 cm dia. × 0.5 cm thickness
17.		Axial solid rod = 40 cm length × 25 mm dia.
18.		Bush = inner dia. of 25 mm & outer dia.34 mm
19.	Chassis and frame	40 cm × 56 cm × 4 cm

2.2 Economic evaluation of the self-propelled rotor power weeder

Cost of operation of the developed machine was estimated assuming that self-propelled rotor power weeder is attached to a prime mower. It was assumed that weeding operation is performed two times in chilli, maize, cotton and groundnut crops at 30 and 60 DAS (days after sowing). Annual use of both prime mower and the implement was considered as 300 h. The total operating cost of the machine was calculated on an hourly basis, encompassing both fixed and variable costs. Fixed costs incorporate depreciation and interest on capital assets, insurance, taxes, and housing. The variable costs, including expenses for fuel, lubrication, repair and maintenance, and the operator, were incorporated into the overall variable cost. To convert the cost of operation into an area basis, it was multiplied by the effective field capacity of the machine and expressed in rupees per hectare. The production cost of the self-propelled rotor power weeder encompassed both the cost of materials used and the cost of labor employed for fabrication works. In this study, the production cost was considered equivalent to the purchase cost. Additionally, the break-even point (BEP) was calculated both in terms of area and time, and the payback period was determined using standard cost estimation methods. (ISI, 1979).

Table 2. Formulas used for calculation of fixed cost

Fixed cost formulas		
Depreciation (D), (₹/h)	$= \frac{C - S}{L \times H}$	Where, D = Depreciation (₹/h) C = Capital cost (₹)

Interest per hour I, (₹/h)	$= \frac{C+S}{2} \times \frac{i}{H}$	S = Salvage Value (₹) L = Useful machine life (year) H = Operating hours per year
Taxes, housing & insurance per hour, (₹/h)	= 3 % of Capital cost	S = 10 % of Capital cost Interest (i) = 12 %

Table 3. Formulas used for calculation of variable cost

Variable cost formulas		
Fuel cost, (₹/h)	= Fuel consumption × Fuel cost per litre	Where, Fuel consumption = 0.6 (l/h) Fuel cost per litre = 70 (₹/l)
Lubrication, (₹/h)	= 30 % of fuel cost	
Repair & maintenance, (₹/h)	= 5 % of Capital cost	
Wages of driver, (₹/h)	= 300 ₹/day of 8 h	

The most significant component within the total costs of a machine is depreciation. It quantifies the reduction in the value of a machine over time, irrespective of its usage (Hunt, 2001) and (Pagare *et al.,* 2019). The cost estimations for both the prime mower and rotor power weeder were calculated utilizing the above-mentioned formulas.

2.2.1 Breakeven point

Breakeven analysis, also known as the point of no profit loss, is conducted to determine the duration of work at a given price necessary to cover all costs or expenditures. The breakeven point occurs where the lines of total cost and custom hiring cost intersect. If the breakeven point value is lower than the annual utility time of the machinery, owning a machine proves beneficial for the farmer. Conversely, if the breakeven point value exceeds the annual utility time of the machinery, owning the machinery may result in a loss for the farmer, making custom hiring a more favorable option. The breakeven point is calculated using the formula provided by (Haquel *et al.,* 2014), (Alam *et al.,* 2018) and (Venkat *et al.,* 2021).

$$BEP = \frac{FC}{CH - C}$$

Where,

BEP = Breakeven point, h yr^{-1},
FC = Annual fixed cost, ₹/yr,
C = Operating cost, ₹/h, and
CH = Custom hiring charges, ₹/h

= (C+25 percent over head) +25 percent profit over new cost

Conditions for Acceptance

If Breakeven value < annual utility hours: accept the use of machinery is financially feasible and profitable.

If Breakeven value > annual utility hours: reject the use of machinery is financially not feasible and no profitable.

2.2.2 Payback period

The payback period refers to the duration it takes for an investment to recover its initial cost through the annual cash revenues generated. In the context of farm machinery, this period is commonly expressed in years. The length of time required to get back the investment on the project. The payback period may be calculated from the equation given by (Singh *et al.,* 2014).

$$BEP=\frac{IC}{ANP}$$

Where

PBP = Payback period, yr,

IC = Initial cost of machine, ₹, and

ANP = Average net annual profit, ₹/yr,

= (CH – C) x AU

AU = Annually used in hours.

2.2.3 Annual utility

It denotes the annual average utilization of farm machinery or any machine, contingent upon the number of working days available for a specific operation with the machine throughout the year. (Haquel *et al.,* 2014). Annual utility of both prime mower and the developed rotor power weeder was considered as 300 hours

3. RESULTS AND DISCUSSION

3.1 Cost economics of self-propelled engine (prime mower)

The lifespan and annual utility of the prime mower were taken into account as 10 years and 300 hours per year, respectively. The fixed cost and variable costs for the prime mower were computed as 30.38 ₹/h and 113.26 ₹/h, respectively. The resulting operating cost of the self-propelled engine was determined to be 143.64 ₹/h.

3.2 Cost economics of developed rotor weeder

The machine's lifespan and annual utility were considered to be 6 years and 300 hours per year, respectively. The fixed cost and variable costs for the machine were determined to be 6.59 ₹/h and 1.34 ₹/h, respectively. The resulting operating cost for the developed rotor weeder was calculated as 7.94 ₹/h.

3.3 Combined cost of prime mower and rotor weeder

Total fixed cost is the summation of fixed costs of prime mower and rotor weeder which is obtained as 11092.5 ₹/year. The total variable cost of the combination was calculated as 114.60 ₹/h. The total operating cost of prime mower and machinery combined was calculated as 151.5 ₹/h. However, in the current manual methods, the completion of the weeding operation necessitates 4187.5 ₹/ha, while utilizing the self-propelled rotor power weeder reduces the cost to 2331.24 ₹/ha for completing the weeding operation in a hectare of land. By adopting this machinery farmers can save 1856 ₹/ha over one hectare of land.

3.4 Breakeven point Calculation

The break-even point was established by graphing the total cost (annual operating cost) and custom hiring cost against the machine's usage. The point where these two cost lines intersect indicates the number of hours of work required for break-even. In the illustrated graph, the line "y = 114.6x + 11093" represents the total operating cost, while "y = 167x" represents the total custom hiring cost (existing manual cost). In both lines, "x" represents the number of operating hours of the machinery. The graphical representation determined the break-even point of the machine to be 209.6 hours per year.

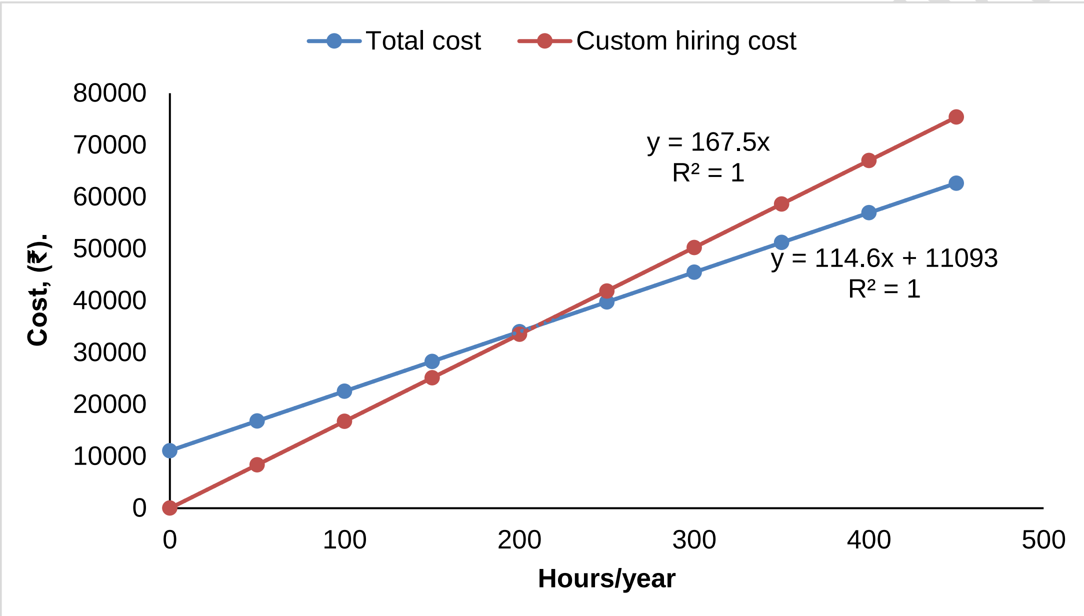

Fig. 2. Break even point between total cost and custom hiring cost

Fixed, variable and operating costs of prime mower, machinery and combine are presented in the following table. The cost of existed method of cultivation is also presented in the following table.

Table 4. Different economical aspects of self-propelled rotor power weeder

S. No.	Economical aspect	Value
1.	Total fixed cost per year, ₹	11092.5
2.	Total variable cost, ₹/h	114.60
3.	Manual weeding cost in cultivation, ₹/ha	4187.5
4.	Manual weeding cost in cultivation, ₹/h	31.25
5.	Total operating cost, ₹/h	151.5
6.	Total operating cost, ₹/ha	2331.24
7.	Total area covered per year, ha	19.50
8.	Cost saving over existed methods, ₹/ha	1856
9.	Cost saving, Percent	45

10.	Breakeven point, h/year	209.6
11.	Breakeven point, ha/year	19.03
12.	Payback period, years	1.02

4. CONCLUSION

The field evaluations of the self-propelled rotary weeder demonstrated satisfactory performance. The break-even point (BEP) for the rotary weeder, calculated based on both area and time considerations, was determined to be 13.63 ha and 209 hours, respectively. The payback period, calculated on an annual basis, was found to be 1.02 years. In terms of cost savings, the rotary weeder's operational expenses were observed to be up to 45 percent lower compared to the manual weeding costs.

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