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Research Paper

Economic Analysis and Feasibility of Rotary Weeder- cum-Fertilizer Drill

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ABSTRACT

Rotary weeder cum fertilizer drill accomplishes both the operations of weeding and fertilizer application simultaneously in a single operation. Performance of developed machine was evaluated in castor crop. Cost has been worked out as per the standard procedure and comparison made in terms of labour saving to determine the economic feasibility of the machines. It had been estimated that the break-even point (BEP) calculated on time and area basis for rotary weeder cum fertilizer drill was 273 h and 53.50 ha, respectively. The payback period calculated on time basis for the rotary weeder- cum- fertilizer drill was found to be a little over 3 years. Cost of weeding and fertilizer drilling through rotary weeder- cum-fertilizer drill can save cost up to 34.22 per cent as compared to the combined cost of existing methods of weeding and fertilizer application methods.

Highlights

- The expenditure in development and fabrication of rotary weeder- cum- fertilizer drill ₹ 41000.
- Using the rotary weeder-cum-fertilizer drill farmer save 650 ₹/ha over the manual methods.
- The payback period for the rotary weeder-cum-fertilizer drill was about 3 years.

Keywords: Rotary weeder- cum- fertilizer drill, payback period, break-even point

Weeding and fertilizer applications are the labour-intensive operations in crop cultivation. Weeding operation accounts for about 25 % of total labour requirement (900-1200 man h/ha) during a cultivation season (Yadav and Pund, 2007). In Indian agriculture the farm power availability from human was noted as 0.091 kW/ha in 2016-17 (Mehta *et al.* 2019). From draught animals the power availability has come down from 0.221 kW/ha in 1971-72 to 0.130 kW/ha in 2016-17 (Mehta *et al.* 2019). Wages of human labour and draught animal are increasing day by day. These trends recommending to adopt mechanization more aggressively in the field of agriculture. Weeding and fertilizer application are done 2 to 3 times in a crop season depending on the type of crop. Existing methods of weeding are manual weeding and mechanical weeding; and fertilizer application is done as manual broadcasting and manual top dressing. Combined expenditure on weeding and fertilizer application by existing methods is 1900 ₹/ha (JAU, 2016). In normal broadcasting of fertilizer on soil surface, it leads to the volatilization of nitrogen in the granules, which causes to loss of nutrient (Black *et al.* 1985). Deep placement method of fertilizer application reduces the fertilizer losses. Timely application of fertilizer and weeding helps in proper vegetative development.

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In India, the holdings are also small and fragmented. High initial cost of weeders and fertilizer applicators, and their higher capacity, made their use uneconomical or impossible for small or medium-sized farms (Mishra *et al.* 2017). Considering all these factors in view, a rotary weeder cum fertilizer drill has been developed in Junagadh Agricultural University. Rotary weeder cum fertilizer drill was developed for wide spacing crops like castor, pigeon pea and cotton. This machine is operated by the mini-tractor power take off (P.T.O) using three-point hitch system and performs inter-cultivation in between the rows and drills the fertilizer near root zone. Simultaneous weeding and fertilizer application helps in energy and time saving (Rawat *et al.* 2007). The main objectives of this paper were to analyze the cost to develop and operate the machine and to determine its' economic feasibility in Indian farms.

MATERIALS AND METHODS

Rotary Weeder-cum-Fertilizer Drill

The rotary weeder cum fertilizer drill is mounted on Mahindra Yuvraj 215 mini tractor (15 hp). It was designed and developed at the Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh. Overall dimensions of the machine length × width × height of the machine was 1050 × 1460 × 1240 mm. The three major components of the developed machine are main frame, weeding system and fertilizer application system. Width of coverage of implement was designed for 1.2 m row crops. An amount of ₹ 41000 were spent for development of the machine.

Performance of the Machine

Performance evaluation of developed machine was conducted through the two field experiments in the castor crop. First experiment was done after the 30 DAS and second experiment was done after the 45 DAS by using standard procedure (ISI, 1993). Experiments were conducted in field by varying forward speed ranged 1.8-2.0 km/h, 2.5-2.7 km/h and 3.0-3.2 km/h (Venkat *et al.* 2020). Calibration of the machine was conducted at laboratory condition and at field conditions to estimate the deviation in fertilizer delivery rates. The performance of the machinery was found to be satisfactory in lab and field conditions. At the time of peak weeding stages for weeding and fertilizer application 10 manual labour are required per one day (8 hours) in manual methods, by using rotary weeder cum fertilizer drill inter-culturing and fertilizer operations are completed by using 1 manual labour up to 5.1 hours of time only.

Fig.1: Developed rotary weeder cum fertilizer drill

Table 1: Particulars of the Rotary Weeder-cum-Fertilizer Drill

Sl. No.	Particulars	Specifications & Descriptions
1	Total weight of machine	126.5 kg
2	Frame unit	Mild steel square pipe (50 mm × 5 mm)
3	Depth adjustment unit	M.S flat and M.S square bar
4	Bevel pinion gear	High carbon steel
5	Chain and sprocket	Alloy steel (952.00 mm)
6	Flange	Alloy steel
7	Cutting blade	L Shaped (High carbon steel)
8	Fertilizer hopper	MS sheet (300 mm × 260 mm × 340 mm)
9	Fertilizer metering unit	Edge cell rotor
10	Motion transmission unit for metering	Sprockets, Shafts and Ground wheel
11	Furrow openers	Reversible shovel type

Economics of the rotary weeder-cum-fertilizer drill

Cost of operation of the developed machine was estimated assuming that rotary weeder cum fertilizer drill is attached to a mini tractor. It was assumed that weeding and fertilizing operations performed two times in castor, pigeon pea and cotton crops i.e. 30 and 45 DAS after sowing of the seeds. Annual use of tractor and the implement was considered as 1000 and 320 h, respectively. Total cost of operation of the machine was computed on per hour basis considering both fixed and variable costs. Fixed cost includes depreciation and interest on capital assets, insurance, taxes and housing. The expenditure on fuel, lubrication, repair and maintenance and operator were added to the variable cost. It was converted into area basis by multiplying it with the effective field capacity of the machine and expressed in rupees per hectare. The development or production cost of rotary weeder-cum-fertilizer drill was the sum of cost of materials used and cost of labor used for fabrication works. Production cost was considered as purchase cost in this study. Break-even point (BEP), area wise as well as time wise and payback period was calculated as per standard cost estimation methods (ISI, 1979).

Annual utility

It is the average usage of farm machinery or any machine annually. It depends upon how many working days are available for a particular operation with the machine in a year. Annual utility of mini tractor and the machine was considered as 1000 and 320 hours respectively.

Table 2: Mathematical formulas for fixed cost calculation (Mehta *et al.* 2019)

Depreciation per year (D)	$= \frac{C-S}{L}$	Where, D = Depreciation (₹/year) C = Capital cost (₹) S = Solvage Value (₹) *L* = Useful machine life (year) *M* = 3 % of C *S* = 10 % of C *i* = 12 %
Interest per year (I)	$= \frac{C+S}{2} \times \frac{i}{100}$	
Taxes, housing & insurance per year, ₹	$= C \times \frac{M}{100}$	

Table 3: Mathematical formulas for variable cost calculation (Singh 2017)

Fuel cost, ₹/h	= Fuel consumption × Fuel cost per litre	Where, *C* = Capital cost (₹) *H* = Annual working hours Fuel consumption = 1.30 l/h Fuel cost per litre = 70 ₹/l R = 5 % of C
Lubrication, ₹/h	= 30% of fuel cost	
Repair & maintenance, ₹/h	$= \frac{C}{H} \times \frac{R}{100}$	
Wages of tractor driver, ₹/h	= 300 ₹/day of 8 h	

Depreciation is the largest component of machine total costs. It measures the amount, by which the value of a machine decreases on-time passage, whether a machine is used or not (Hunt, 2001). By using above the formulae cost estimations of mini tractor and rotary weeder cum fertilizer drill were estimated.

Determination of Breakeven point

Breakeven analysis, also called a point of no profit-loss is performed to assess the duration of work at a given price that is necessary to meet out all the costs or expenditures. The breakeven point is the intersection of the lines at which the line of total cost and the line of custom hiring cost intersect each other. If the breakeven point value is less than the annual utility time of machinery then the farmer benefitted by owning a machine. If the breakeven point value is found more than the annual utility time of machinery then owning machinery can lead to a loss for the farmer, at that time going for custom hiring is the better option for him.

Payback period

It is the time taken for an investment to return its original cost through annual cash revenues generated. The payback period was calculated from the following formula. Generally, it is expressed in years for farm machinery.

$$\text{Payback period} = \frac{\text{Initial investment}}{\text{Average net annual benifit}}$$

Where,

Average net annual benefit, ₹ = (CHC – TOP) × Annual utility

CHC = Custom hiring charge, ₹/h = (25 per cent over total cost of operation ₹/h)

TOP = Total operating cost, ₹/h

RESULTS AND DISCUSSION

From the testing and evaluation of machinery in field conditions, the field capacity of the developed machine was obtained 196 × 10-3 ha/h. Depth of weeding ranged from 5.4 to 5.9 cm. Weeding efficiency and plant damage of developed machine were ranged 86-91 % and 3-5% respectively. The depth of fertilizer drilled was ranged between 2.7-3.1 cm.

Cost economics of mini tractor

Life and annual utility and of tractor were considered as 10 years and 1000 hours per year respectively. Fixed cost and variable costs of a tractor were calculated as 46.5 ₹/h and 168.3 ₹/h. The operating cost of the tractor obtained was 214.8 ₹/h.

Cost economics of rotary weeder cum fertilizer drill

Life and annual utility of machine were taken as 10 years and 320 hours per year respectively. Fixed cost and variable costs of the machine was calculated as 23.83 ₹/h and 6.41 ₹/h. Operating cost of the machine obtained was 30.24 ₹/h.

Combined cost of mini tractor and machinery

Total fixed cost is the summation of fixed costs of tractor and machinery which is obtained as 54,125.6 ₹/year. The total variable cost of the combination was calculated as 174.71 ₹/h. The total operating cost of tractor and machinery combined was calculated as 245.04 ₹/h. But in existing manual methods it requires 1900 ₹/ha for completion of weeding and fertilizer applications, with that of mini tractor drawn rotary weeder cum fertilizer drill it requires 1250 ₹/ha to complete the weeding and fertilizer operations in hectare land. By adopting this machinery farmers can save 650 ₹/ha over one hectare of land.

Breakeven point Calculation

Break-even point was determined by plotting the total cost (annual operating cost) and custom hiring cost against the usage of the machine. The location of the intersecting point made by the two cost lines gives the number of hours of work required for break-even. Below picture "y = 174.71x + 54126" is the line of the total operating cost and "y = 373 x" is the line of total custom hiring cost (existed manual cost). In both, the lines "x" indicates the number of operating hours of machinery. From the below graphical representation breakeven point of the machine was calculated as 273 hours per year.

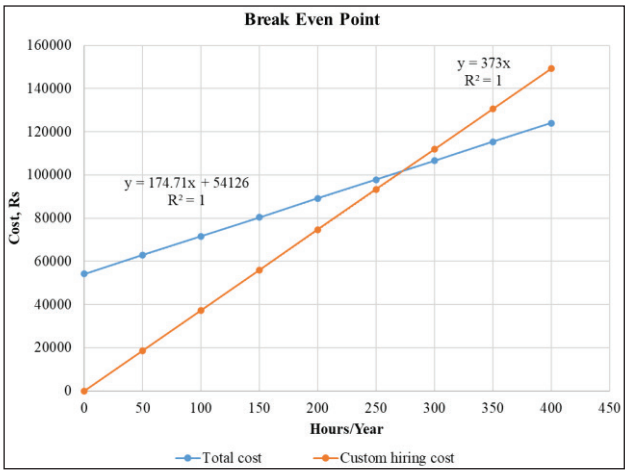

Fig. 2: Break-even point of owning the machine

Fixed, variable and operating costs of tractor, 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: Mathematical calculations for cost estimation of mini tractor

Sl. No.	Economical aspect	Value
1	Total fixed cost per year, ₹	54125.6
2	Total variable cost, ₹/h	174.71
3	Cost of existed method of cultivation, ₹/ha	1900
4	Cost of existed method of cultivation, ₹/h	373
5	Total operating cost, ₹/h	245.04
6	Total operating cost, ₹/ha	1249.70
7	Total area covered per year, ha	62.72
9	Cost saving over existed methods, ₹/ha	650.30
10	Cost saving (%) by machine	34.22
11	Breakeven point, h/year	273
12	Breakeven point, ha/year	53.50
13	Payback period, years	3.06

CONCLUSION

Adoption of the rotary weeder cum fertilizer drill was found to be profitable in terms of cost, labour requirement and timeliness for weeding and fertilizer application operations. The break-even point (BEP) calculated on the area and time basis for the rotary weeder cum fertilizer drill was 53.50 ha and 273 h respectively. The payback period calculated on year basis for the rotary weeder cum fertilizer drill was 3.06 years. Cost of operation by rotary weeder-cum-fertilizer drill can save up to 34.22 percent as compared to the combined cost of existed weeding and fertilizer application methods.

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Appendix

Table 5: Mathematical calculations for cost estimation of mini tractor

Fixed cost	Depreciation per year, ₹	$= \frac{C-S}{L}$ $= \frac{2,50,000-25,000}{10}$	22,500
	Interest per year, ₹	$= \frac{C+S}{2} \times \frac{i}{100}$ $= \frac{2,50,000-25,000}{2} \times \frac{i}{100}$	16,500
	Taxes, housing & insurance per year, ₹	$= C \times \frac{M}{100}$ $= 2,50,000 \times \frac{3}{100}$	7,500
	Total fixed cost per year, ₹		46,500
	Total fixed cost ₹/h		46.5
Variable cost	Fuel cost, ₹/l	= 1.3 l/h × 70 ₹/l	91 ₹/h
	Lubrication, ₹/h	= 0.30 × 91 ₹/h	27.3 ₹/h
	Repair & maintenance, ₹/h		12.5 ₹/h
	Wages of tractor driver, ₹/h	= 300 ₹/day of 8 h	37.5 ₹/h
	Total variable cost, ₹/h		**168.3 ₹/h**
Total operating cost of mini tractor, OCM			214.8 ₹/h

Table 6: Mathematical calculations for cost estimation of developed rotary weeder cum fertilizer drill

Fixed cost	Depreciation per year, ₹	$= \frac{C-S}{L}$ $= \frac{41,000-4,100}{10}$	3,690
	Interest per year, ₹	$= \frac{C+S}{2} \times \frac{i}{100}$ $= \frac{41,000+4,100}{2} \times \frac{12}{100}$	2,706
	Taxes, housing & insurance per year, ₹	$= C \times \frac{M}{100}$ $= 41,000 \times \frac{3}{100}$	1,230
	Total fixed cost per year, ₹		7,626
	Total fixed cost, ₹/h		23.83
Variable cost	Repair & maintenance	$= \frac{C}{H} \times \frac{R}{100}$ $= \frac{41,000}{320} \times \frac{5}{100}$	6.41 ₹/h
	Total variable cost		**6.41 ₹/h**
Total operating cost of implement, OCR			30.24 ₹/h

Total operating cost of rotary weeder cum fertilizer drill

Total cost of machine (TCM) = OCM + OCR

= 214.8 ₹/h + 30.24 ₹/h

= 245.04 ₹/h

Total fixed cost of the machine is the sum of fixed costs of mini tractor and rotary weeder cum fertilizer drill

Total fixed cost per year, ₹ = 46500 + 7620.6 = 54125.6

Total variable cost of the machine is the sum of variable costs of mini tractor and rotary weeder cum fertilizer drill

Total variable cost ₹/h = 168.3 + 6.41 = 174.71

Payback period Calculation

Initial cost of machine, ₹ = 41,000

Custom hiring charge (CHC), ₹/h = (25 % over total cost of operation ₹/h)

= (245.04 × 1.25)

= 294.05 ₹/h

Average net annual benefit, ₹ = (CHC – TCM) × Annual utility

= (294.05 – 245.04) × 273

= 49.01 × 273

= 13379.73 ₹

$$\text{Payback period} = \frac{\text{Initial investment}}{\text{Average net annual benifit}}$$

$$= \frac{41000}{2303.47}$$

= 3.06 years

Total area covered per year, ha = Field capacity (ha/h) × Annual utility (h)

= 0.196 × 320

= 62.72