Economic Affairs, Vol. **70**(03), pp. 255-261, September 2025
DOI: 10.46852/0424-2513.3.2025.12

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RESEARCH PAPER

Cost Economic and Benefit Cost Ratio of Developed Round Basin Maker cum Fertilizer Applicator for Orchard Crops

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Received: 12-06-2025 **Revised:** 10-08-2025 **Accepted:** 30-08-2025

ABSTRACT

A multi-functional implement was developed to perform both round basin formation and fertilizer application in a single field operation. The machine was tested in various orchard crops, including mango, guava, and citrus, to evaluate its field performance. Economic evaluation was conducted out following standard cost estimation methods, focusing on labour savings to assess feasibility. The break-even point (BEP) of the implement was estimated to be ₹ 693 per hour and 6.295 hectares on a time and area basis, respectively. The payback period was calculated to be approximately 2.64 years, indicating a promising return on investment. The machine demonstrated a cost reduction of up to 54.75% when compared to the combined expenses incurred by traditional weeding and manual fertilizer application practices.

HIGHLIGHTS

- Comprises hydraulic and electrical systems powered by tractor hydraulics and battery.
- A tractor-operated implement was developed to perform round basin formation and fertilizer application simultaneously.
- Aims to reduce labor, time, and cost compared to traditional manual methods.
- Custom hiring is recommended for farmers with lower usage to avoid losses.

Keywords: Round basin maker, fertilizer applicator, cost economics, cost of operation, traditional method, pay back period, B:C ratio

The horticulture production gains 21.2 metric tonnes (MT) in 2007-08 to 306.8 in 2017-18. India holds the second-largest global position in vegetable and fruit production, which is a significant achievement. The country ranks at first position in the production of banana, mango, lime and lemon, papaya, and okra. India has witnessed increases in horticulture production over last few years (Anonymous 2022). In Andhra Pradesh, horticultural crops are cultivated extensively across all three regions, forming a significant part of commercial agriculture. The horticulture sector contributes approximately 4% to the state's Gross Domestic Product (GDP) and occupies nearly 13% of the total cultivated area (Anonymous 2021). Orchard crops exhibit diverse planting patterns, with varying distances

How to cite this article: Vinayak, M., Haribabu, B., Ashokkumar, A., Madhava, M., Ratnakumari, N. and Ramana, C. (2025). Cost Economic and Benefit Cost Ratio of Developed Round Basin Maker cum Fertilizer Applicator for Orchard Crops. *Econ. Aff.*, **70**(03): 255-261.

Source of Support: None; **Conflict of Interest:** None

between plants and rows, and plant density largely influenced by plant type, soil fertility, and variety. The newly planted fruit trees are delicate and require careful management to ensure healthy establishment and growth. Among various cultural practices, proper irrigation and nutrient management play a crucial role in the success of orchard cultivation. Different form operations involved in orchard production from plantation to harvesting i.e. digging for plantation, basin making for irrigation and fertilizers application and intercultural operations like weed control, spraying. Among the all farm operations one the major farm operation in orchard production is making around the tree palm. The distribution of water and nutrients on plantation crops is a literally impressive process. It incorporates digging of a basin of recommended dimensions and addition of fertilizers in that basin in required amount. The methods used for fertilization are relatively prehistoric. Advanced machineries do exist for this application, but they find their uses in a very limited scope because of high initial cost and non-viable nature. Basin diameter and fertilization rate application depths for different ages of orchard crops are different. Basins are generally round or square in shape. More formers are required for round basin making and fertilizers application (Srinivas *et al.* 2020). Therefore, a need was handled to address the shortcomings of conventional methods and take steps for developing a tractor operated round basin making cum fertilizer applicator. The machine which we are developing target to rectify these pile-up and simplify process of round basin making and supply of fertilizers in the cheapest way possible.

MATERIALS AND METHODS

Development of Tractor Operated Round Basin Maker cum Fertilizer Applicator for Orchard Crop

The developed machine to accomplish the operations of round basin formation and fertilizer distribution. The machine consists of base frame, round bevel gear, gate wheels, driven gear, supporting frame, three-point linkage frame, hydraulic cylinders, hydraulic motor, fertilizer hopper, delivery tubes, DC Motor, PWM DC regulators and many other parts.

For basin making, the power from tractor rear hydraulic port to hydraulic cylinders and hydraulic motor through hydraulic system. In order to operate the fertilizer applicator, the drive provided from the tractor battery through PWM DC regulator and DC motor to the fertilizer metering shaft. The hopper, fertilizer mounting frame, DC Motor and delivery pipes and other parts were fitted on the three-point linkage frame. The developed machine and field evaluation shown in Fig. 1 and 2 (Vinayak M. *et al.* 2025).

Fig. 1: Developed tractor operated basin making cum fertilizer applicator

Fig. 2: Field evaluation by developed machine

Developed Machine Cost Economics

The primary focus of comparing the developed equipment's economics with traditional basin formation and fertilizer distribution methods used by farmers is to govern the equipment's economic viability. The cost estimation of developed equipment was compared with existing available methods (manually method) of basin formation and fertilizer distribution methods field conditions.

The cost of process of developed machine and existing methods of basin formation cum fertilizer application, Using the straight-line method, the analysis considered both fixed and operational (variable) costs (Venkat R. *et al.* 2021).

$$\text{Operation cost (₹)} = \frac{FC + V.C}{H} \quad \ldots(1)$$

Where

F.C = Fixed cost, ₹ h^{-1}

V.C = Variable cost, ₹ h^{-1}

H = Annual Working hours, h

1. Fixed cost

(a) Depreciation (₹ h^{-1})

Depreciation refers to the decline in a machine's value over time due to usage and wear. It is computed by subtracting the salvage value from the total preliminary cost of machine. Assuming a machine lifespan of 10 years and an annual operational time of 400 hours for the developed prototype, depreciation was estimated using the formula given below (Venkat R. *et al.* 2021).

$$D = \frac{C - S}{L \times H} \quad \ldots(2)$$

Where

C = Initial cost of unit, ₹

S = Solvage value (10% of C in ₹)

L = Life of machine (10 years)

H = Annual working hours, h

(b) Interest cost

It was calculated from capital investment with 10 % as interest. The interest cost is determined by following formula (Venkat R. *et al.* 2021).

$$\text{Interest cost (I)} = \frac{C + S}{2} \times \frac{i}{H} \quad \ldots(3)$$

Where,

I = Interest cost, ₹ h^{-1}

i = Rate of interest, %

2. Variable Cost

(a) Repair and maintenance

The cost was counted as 10 % for tractor and 5 % for developed machine (Venkat R. *et al.* 2021).

(b) Labour cost

By considering daily wages as ₹ 500 per day for each worker. Two workers were required to operate the machine developed (Venkat R. *et al.* 2021).

(c) Fuel cost

Fuel cost was calculated created on the usual fuel utilization rate through operation (in L h^{-1}), using the prevailing local diesel price of ₹ 100 per litre (Venkat R. *et al.* 2021).

(d) Lubricating cost

Total lubrication costs for field operation are about 5 % of fuel costs (Venkat R. *et al.* 2021).

(e) Housing and insurance cost

The cost calculated by considering 1% each of preliminary cost of prime mover or machine (Venkat R. *et al.* 2021).

Gross Returns

It was calculated for all the actions based on the minimum accompanying price of the basin formation cum fertilizer distribution for orchard crops (Venkat R. *et al.* 2021).

Net Returns

It can calculated by take away cost of development from gross returns for all the treatments (Venkat R. *et al.* 2021).

Benefit Cost Ratio

B:C ratio shows the edge or profit per rupee invested. It is the ratio of gross returns to the cost of cultivation, and it can calculate by following formula (Venkat R. *et al.* 2021).

$$\text{B:C Ratio} = \frac{\text{Gross Returns}\left(\text{Rs ha}^{-1}\right)}{\text{Cost of basin making cum fertilizer application}\left(\text{Rs ha}^{-1}\right)} \quad \ldots(4)$$

RESULTS AND DISCUSSION

The cost of round basin formation cum fertilizer distribution alone is ₹ 76,000. The cost economics of the developed basin formation cum fertilizer distribution was calculated by taking the cost of the tractor and the considering an annual use of machine as 400 h year^{-1} the results obtained for fixed and operational costs were cost of procedure of tractor basin formation cum fertilizer distribution as in material and method section it found ₹ 693 h^{-1} and ₹ 6295 ha^{-1}. The B:C ratio was 1.2:1. About 54.75 % recovering in cost was noted with developed machine. Custom hiring cost (₹ h^{-1}) was calculated by adding 25 percent overhead charges and 25 percent profit over another cost and got to be ₹ 1,082 h^{-1}. Payback period was found as 2.64 years. The detailed calculation in Appendix I (Venkat R. *et al.* 2021).

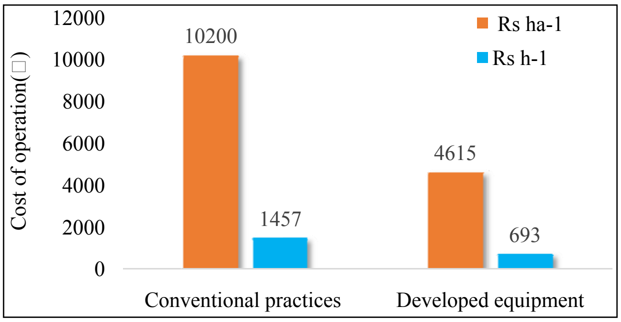

Fig. 3: Cost economics comparisions

Breakeven analysis was done using two methodologies i.e., theoretical and graphical to ensure the degree of correlation. From the formula, breakeven was calculated as 147.7 hours per year with a revenue of ₹ 1,62,300 per year depicted in Fig. 4.

To construct a breakeven chart, number of hours per year (x) is plotted on X-axis and revenue or cost (₹.) on Y-axis. Initially, breakeven hours per year and revenue per year are mapped on the chart meeting at a point (150, 1,62,300) as depicted in Fig. 4. Total fixed cost line i.e., ₹ 91,180 is constant for any number of working hours and represented by a straight line passing parallel to X-axis. Custom hiring cost starts at point (0,0), increases with increasing working hours and passes through theoretical breakeven point. Total cost line represents 'variable cost(x) + fixed cost' with increasing working hours and coincides with total CHC line and theoretical breakeven point. The detailed calculation was presented in Appendix I.

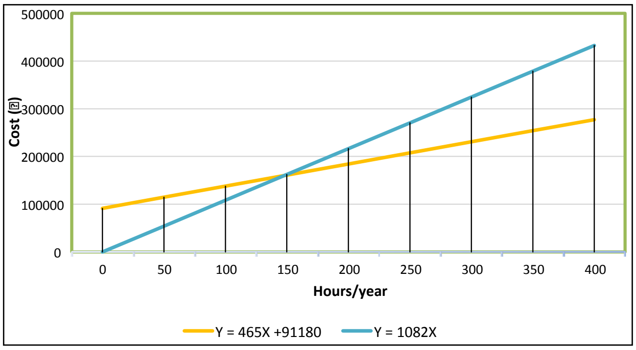

Fig. 4: Breakeven analysis

CONCLUSION

Utilizing the round basin formation cum fertilizer distribution resulted in an operational cost of ₹ 6295 per hectare, enabling farmers to achieve cost savings of up to 54.75 percent (₹ 5585.4/ha) relative to traditional basin formation and fertilizer application methods. The breakeven point was reported 147.7 h/yr, Farmer gets benefitted by owning a machine when the value of breakeven point is lower than the annual utility, if it is more it leads to loss, in such a condition custom hiring is the better option. Obtained of payback was 2.64 years, it shows that farmer get back their investment within 2.64 years by owing round basin formation cum fertilizer applicator machine. The obtained value of benefit cost ratio was 1.2:1. The suggestions for future study are other horticultural machinery can also be investigated to test feasibility analysis.

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Y = 465X

0 50

APPENDIX-I

The cost economics of machine was worked out based on fallowing assumption

1	Cost of tractor	1000000
2	Annual usage of tractor	1000
3	Daily working hours of tractor	8
4	Life of tractor	10
5	Solvage value of tractor (10 % of initial cost)	100000
6	Rate of intrest, i =	10 % per annual
7	Insurance charges tax charges and shelter charges=	5% of capital cost
8	Fuel diesel cost =	₹ 100 per litre
9	Lubrication cost =	30% of fuel cost
10	Repair and maintenance cost =	8% of capital cost of machine
11	Driver wages per day 700 for 8 h day^{-1}	87.5
12	Cost of machine	76000
13	Annual usage of machine	400
14	Life of machine	10
15	Solvage value of machine	(10 % of initial cost)
16	Cost of round basin maker cum fertilizer applicator	76000

Total cost of operation for developed round basin maker cum fertilizer applicator

= Total fixed cost + Total variable cost

= 227.95+465 = ₹ 692.5 per hour

Total average cost of operation of developed machine per hectare

Average no. of plants per ha = 210

Average time taken for basin making cum fertilizer application per plant = 1.84 min

Average time required per covering 210 plants is = 386.4 min i.e., 6.44 hours

Time required per covering the 10,00 m^2 area = $\frac{10,000}{6.44}$ = 1552.7 m^2 h^{-1} = 0.15 ha h^{-1}

Actual field capacity = 0.15 ha h^{-1}

Total cost of operation for developed machine = 692.5/0.15 = 4614.6 ha^{-1}

Total cost of basin making cum fertilizer applicator by traditional methods

Basin making = 20 basin day^{-1} labour^{-1}

Number of trees per hectare = 210

Total labour per hectare for basin making = 210/20 = 10.5 =10

Total labour required for fertilizers application = 7

Total labours required for basin making cum fertilizer application = 17

Total cost = (17 labour per ha at ₹ 600 per day) = 17*600 = 10200

Assuming 7 h are needed for basin making cum fertilizer 1 ha of land manually for 17 labours

Saving cost

Saving cost = 10200 – 4614.6 = ₹ 5585.4 per ha

Saving cost percentage = 5585.4 / 10200)*100 = 54.75 percent

Break even point

$$\text{BEP} = \frac{\text{FC}}{\text{CH}-\text{V}}$$

Total fixed cost = 91180

Custom hiring charges = (cost of operation per hour + 25 % overhead charges) × (25 % profit over view cost)

= 692.5 +(692.5*0.25) ×1.25 = ₹ 1082 per hour

Variable cost per hour = 465

Actual field capacity = 0.15

$$\text{BEP} = \frac{91180}{1082-465} = 147.7 \text{ h year}^{-1}$$

Annual utility = Effective field capacity *Annual utility

= 0.15*400 = 60 ha

The, BEP can be obtained at (147.7*100)/400 = 36.9 % of the annual utility of 400 hours of the developed round basin maker cum fertilizer applicator

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

Initial investment = Initial cost of tractor for 400h + Initial cost of machine

= (1000000 × 400)/692.5 + 76000

= 653617.3

Average net annual benefit = CH – V × annual usage of machine

= 1082 – 465 × 400 = 246800

Payback period = 653617.3/246800 = 2.64 years

$$\text{B: C ratio} = \frac{\text{Benefit cost}}{\text{Cost of machine operation}}$$

= 5585.4/4614.6 = 1.2