Economic Analysis of a Manually Operated Maize Planter for Small-Scale Farmers

Sakshi Tomar[1], Asif Beg[2], Alpana Joshi[3]

[1,2,3]School of Agriculture and Environmental Sciences, Shobhit Institute of Engineering and Technology (Deemed-to-be University) Meerut, Uttar Pradesh, India.

ABSTRACT

The cost economics of manually operated maize planter generally show potential advantages in terms of accuracy, productivity, and financial sustainability. This study analyses the economic viability of planter, which aim at increasing efficiency, reducing labour dependency and decreasing cost of operation.Cost economic analysis has been made for planter, where cost analysis included fixed cost such as depreciation, interest, housing, taxes and insurance cost, while variable cost included labour cost, repair and maintenance costs. The designed planter was estimated to have cost ₹10,000.00 and operational cost was found to be ₹74.99 h^{-1}. The saving over traditional planting was of 95%. The payback period, break-even point and benefit-cost ratio were found to be 2.155 yr, 41.47 h yr^{-1}, 4.638 respectively. It can be inferred that planter is ergonomically efficient and economically profitable. The use of cost effective, labour-driven planter such as this will increase efficiency on the farms while reducing input costs. The study attempts to define important financial parameters including payback period, break-even point, and benefit-cost ratio by modelling the total cost of ownership which includes capital investment, operational expenses, input savings, yield increases from better accuracy, and the value of timeliness.

Keywords: Cost economics, fixed cost, variable cost, payback period, break-even point and benefit cost ratio.

INTRODUCTION

The planting process is an extremely crucial activity during crop cultivation, as it determines the plant population and establishment and yield potential. For several decades, sowing has been practiced using simple methods like hand dibbling and broadcasting. With time, more complex sowing technologies have been developed like mechanical seed drills and precision planters. Despite offering high accuracy and fast performance, precision planters are expensive, making them unaffordable for small and marginal farmers. This scenario calls for cost-effective and practical solutions such as manual planters that lie between traditional practices and mechanical seed drill technology (Adekanye and Akande, 2015 and Omara *et al.,* 2016). A planter is an advanced form of a seed drill where seeds are sown at specified depths and intervals, ensuring consistent plant-to-plant and row-to-row distances for effective growth. Appropriate seeding facilitates proper spacing, reduces seed usage, promotes optimal germination and nutrient utilization, and minimizes labor intensity. Conventional sowing practices often result in inconsistent plant populations and extra labor demand. Research on manual maize planters and different

crops indicates advancements in spacing accuracy, reduction in labor input, and higher field efficiency than conventional approaches (Omara *et al*., 2016 and Sari *et al.,* 2013).
Ergonomics of the design are important in the case of planters controlled manually as it has an impact on the level of comfort of the operator. Bad ergonomics associated with agricultural machinery raise the physiological strain and increase musculoskeletal discomfort, making it difficult to work and creating health problems for the farmers. The studies of ergonomic hazards in agriculture emphasize the importance of minimizing the heart rate and rate of oxygen uptake along with overall levels of discomfort associated with manual labor (Kirkhorn *et al.,* 2010). Ergonomic benefits for various farming practices, including maize shelling, transplanting, and tree planting, show that better designs reduce physiological strain for workers (Tiwari *et al.,* 2014; Inthiyaz *et al.,* 2021 and Sheahan *et al.,* 2017). Interventions in the workplace directed at alleviation of fatigue resulted in successful reduction of musculoskeletal strain. This means that the human energy expenditure should be taken into account in addition to machine efficiency. Ergonomics analysis, techno-economic analysis becomes another critical criterion when choosing agricultural machinery. The results of studying different agricultural machinery including stubble collector, rotavator, and minimum tillage machinery show that the acceptance of these machines by farmers depends on the operational costs, reduction in labor input, and benefit-cost ratio (Pakhare *et al.,* 2019; Khurdal *et al.,* 2024 and Jyotsna *et al.,* 2025). However, in the case of analyzing high-level and autonomous machines, it should be noted that although they have shown high efficiency, high capital costs prevent them from being used by poor farmers (Shockley *et al.,* 2019). Thus, studying the issue of economical planters' use becomes extremely important when planning to plant maize seeds. Although there is a large amount of research on design features, performance, and ergonomics of manually-operated planting machinery, no attention has been paid to evaluating their cost economics. However, fixed costs, variable costs, break-even point, and benefit-cost ratio should be taken into account while assessing the economic feasibility of any technological process. Therefore, the aim of the current study is to evaluate the economic feasibility of a manually operated maize planter based on its performance and ergonomic features.

MATERIAL AND METHOD

Fixed and variable costs of manually operated maize planter were used to calculate the overall cost of operation (Fig. 1). The break-even point, benefit-cost ratio, and cost of operation, payback period were all estimated using standard techniques. The process is described in detail below.
[1. Handle 2. Hooper 3.Frame 4. Seed plate 5. Furrow opener 6. Rear wheel and 7. Ground wheel]

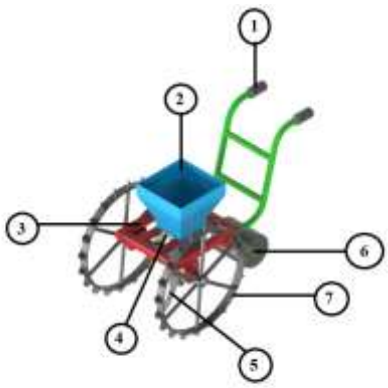

Fig. 1 Developed planter

The planter's total operating costs consist of two expenses:

1. Fixed cost
2. Variable cost

Fixed cost: This expense is associated with machine ownership. This expense may arise whether the machine is utilised or not. Annual utilisation has an inverse relationship with fixed costs, depreciation, interest, housing, taxes and insurance cost are all included (Ajay and Ramireddy, 2024).

Variable cost: Variable costs are expenses that are directly correlated with usage. The machine only incurs these expenses when it is in use. Labour cost, repair and maintenance cost, are examples of variable expenses (Ajay and Ramireddy, 2024).

Calculation of manually operated maize planter

Assumptions

A. Fixed cost

a) Average annual use of the planter, h = 110
b) Life of machine, years = 10 years
c) Salvage value @ 10% of initial cost
d) Rate of interest @ 10% of capital cost
e) Housing, taxes and insurance cost @ 3% of initial investment
f) Initial investment on manually operated maize planter = 10,000/-

B. Variable cost

a) Labour cost per day = 400
b) Repair and maintenance cost @ 10% of initial investment per year

Fixed cost

Depreciation

It is the decrease in a machine's value over time. There are four methods of determining depreciation, cost and all the approaches have their own benefits and demerits. However, the straight line approach is the most preferred method of computing the depreciation cost of the machinery. In the straight line technique, the amount of depreciation cost is constant throughout the useful life of the machine. (Beg *et al*.,, 2026), Depreciation was calculated by using equation (1).

$$Depreciation, ₹\,\text{h}^{-1} = \frac{C-S}{L\times H} \quad \ldots..(1)$$

$$= \frac{10000-1000}{10\times 110} = 8.18$$

Where,

C = Initial cost of machine, ₹
S = Salvage Value, 10% of initial cost
L = Life of machine, years
H = Annual use of machine, h

Interest

It is proportionate to the machinery's residual worth and is also known as opportunity cost. Although it varies, the interest rate typically falls between 9 and 12%. The following equation is used for calculating interest on an hourly basis. Rathod *et al.* (2024), Interest was calculated by using equation (2).

$$Interest, ₹\ \mathrm{h}^{-1} = \frac{C+S}{2\times H} \times i \qquad ....(2)$$

$$= \frac{10000+1000}{2\times 110} \times \frac{10}{100} = 5$$

Where,

i= Annual rate of interest, %

Housing, taxes and insurance cost

To calculate the cost of insurance, taxes, and shelter a sum equal to three percent of the cost of the machinery would be enough for meeting out the expenses annually. The following equation is used to determine these costs on hour basis. Housing, taxes and insurance cost was calculated by using equation (3) Beg, *et al.* (2026).

$$\text{Housing, taxes and insurance cost per year, } ₹\ \mathrm{h}^{-1} = \frac{C\times 3}{H\times 100} \qquad ....(3)$$

$$= \frac{10000\times 3}{100\times 110} = 2.73$$

Total fixed cost

$$= \text{Sum of cost involved as depreciation, interest, housing, taxes and insurance cost}$$

= 8.18 + 5 + 2.72 = 15.9 ₹ h^{-1}

Variable cost

Labour cost

The labour cost was estimated to be Rs 400 per day. Total working hours should be calculated as 8 hrs in a day. (Ajay and Ramireddy, 2024), Labour cost was calculated by using equation (4).

$$\text{Labour cost, } ₹\ \mathrm{h}^{-1} = \frac{wages\ cost}{no.of\ hour\ worked} \qquad .....(4)$$

$$= \frac{400}{8} = 50$$

Repair and maintenance costs

Repair and maintenance expenditures vary from 5 to 10 % of the machine initial cost each year. It is usually taxed @ 10% per annum, Dikkar *et al.* (2024), Repair and maintenance costs was calculated by using equation (5)

$$Repair\ and\ maintenance\ cost\ @10\%\ of\ initial\ investment\ per\ year, ₹\ \mathrm{h}^{-1} = \frac{10\times C}{100\times H} \qquad .(5)$$

$$= \frac{10\times 10000}{100\times 110} = 9.09$$

Variable cost = Sum of labour cost and repair and maintenance cost

= 50 + 9.09 = 59.09 ₹ h^{-1}

Cost involved in manually operated maize planter

Operation cost of manually operated maize planter, ₹ h^{-1}

= Fixed cost + Variable cost

= 15.9 + 59.09 = 74.99 ₹ h^{-1}
Field capacity of planter, $ha.h^{-1}$ = 0.15
The cost of operation of maize planter, ₹ ha^{-1}

$$= \frac{Operation\ cost\ of\ manually\ operated\ maize\ planter}{Field\ capacity\ of\ planter} = \frac{74.99}{0.15} = 499.93$$

Cost involved in manually operated maize planter (broadcasting)
Man, hour required to plant one hectare of crop = 200
Wage rate of 400 per man per day for 8 hours.
The cost of manual planting ₹ ha^{-1}, = $\frac{200 \times 400}{8}$ = 10000

Saving over manual planting, % = $\frac{10000 - 499.93}{10000}$ = 95%

Pay-back period

It is the time taken for an investment to recover its original cost through annual cash profits generated. The payback period was derived from the following formula. Generally, it is given in years for farm machinery. (Ajay and Ramireddy, 2024), Pay-back period was calculated by using equation (6).

$$P = \frac{I}{E} \qquad \ldots (6)$$

Where,
P = pay-back period, year
I = Initial cost of machine= 10,000/-
E = Average net annual benefit, yr^{-1}, = $(CH - C) \times AU$
$= (117.16 - 74.99) \times 110 = 4638.7 yr^{-1}$

$$CH = (1.25 \times C) + (0.25 \times 1.25 \times C)$$

= (1.25×C)+(0.25×1.25×C)=(1.25×74.99)+(0.25×1.25×74.99) = 117.16
Where,
AU = annual utility
CH = Custom hiring charges, ₹ h^{-1}
C = Cost of operation, ₹ h^{-1} = 74.99

$$P = \frac{I}{E} = \frac{10000}{4638.7} = 2.155 \text{ yr}$$

Break-even point

Breakeven analysis, often known as the point of no profit-loss, is used to determine how much work must be done at a specific price in order to cover all expenses. The breakeven point is the intersection of the lines at which the line of total cost and the line of total income. More work than this would result in profit, and vice versa. The breakeven point can be computed using the following equation. (Ajay and Ramireddy, 2024), Break-even point was calculated by using equation (7).

$$Break\ even\ point (h\ yr^{-1}) = \frac{FC}{(CHC - C)} \qquad \ldots (7)$$

Where,
FC = Annual fixed cost, ₹ yr^{-1} = $Average\ annual\ use \times fixed\ cost$
$= 110 \times 15.9 = 1749$
C = Operating cost, ₹ h^{-1}

CHC = Custom hiring charges, ₹ h^{-1}

$$\text{Break even point } (h\ yr^{-1}) = \frac{1749}{(117.16-74.99)} = 41.47$$

Benefit cost ratio

The Benefit–Cost Ratio (BCR) of a machine is an economic indicator used to measure how financially profitable or worthwhile a machine is. It compares the total benefits obtained from using the machine to the total costs involved in purchasing, operating, and maintaining it. Benefit cost ratio is calculated by using equation 8.

$$BCR = \frac{Net\ income(Rs)}{Gross\ cost(Rs)} \qquad \ldots (8)$$

$$= \frac{4638.7 \times 10}{10000} = 4.638$$

RESULT AND DISCUSSION

Cost economics of manually operated maize planter

The total expense incurred for planting was estimated considering both the fixed and variable costs. In order to calculate the savings gained in comparison with the broadcasting method, computations were made. Furthermore, the benefit-to-cost ratio, payback period, and breakeven point were determined. Table 1 illustrates the financial data relating to the planter's cost.

Table 1: Important parameters related to cost economics of the developed planter

S. No.	Parameters	Values
1	Fixed cost of planter, ₹ h^{-1}	15.9
2	Variable cost of planter, ₹ h^{-1}	59.09
3	Operating cost of planter, ₹ h^{-1}	74.99
4	Cost of operating planter, ₹ ha^{-1}	499.33
5	Cost involved in broadcasting, ₹ ha^{-1}	10000
6	Cost saving, ₹ ha^{-1}	9500.67
7	Cost saving, %	95%
8	Payback period, yr	2.155
9	Break-even point, h yr^{-1}	41.47
10	Benefit cost ratio	4.638

The economics of operation of the manually operated maize planter have shown that the machine is economical, labour-saving, and appropriate for small and marginal farmers. From the results of the economic analysis, it is evident that the operating cost of the maize planter was ₹74.99 h^{-1}. Out of the total cost, the variable cost accounted for 79% of the total at ₹59.09 h^{-1} while the fixed cost constituted 21% at ₹15.9 h^{-1}. Therefore, the manually operated maize planter is labor-dominant rather than capital dominant, which is an important aspect of small farm machinery.In addition, because of the low cost, ownership of the maize planter would not place any undue financial strain on farmers. The cost of operation of the developed maize planter have been calculated to be ₹499.33 ha^{-1}, which is extremely low compared to the conventional practice of broadcasting or dibbling requiring ₹10,000 ha^{-1}. The cost

reduction amounts to 95%, or approximately ₹9,500 ha^{-1}. Also, the low cost per hectare can be traced back to uniform seeding, resulting in reduced seed wastage and achieving the right plant population.
The payback period of the planter was determined to be 2.155 years. According to farm mechanization economics, any equipment with a payback period of less than three years is deemed highly economical. Thereafter, the equipment continues operating for the remainder of its life span, which is about eight years, at a very low effective cost, thus increasing its profitability in terms of lifetime cost. The break-even point is only 41.47 h $year^{-1}$. Therefore, even a small-scale farmer providing custom hiring services can reach the break-even point using the planter without much effort.The benefit-cost ratio (BCR) of 4.638 further underscores the high economic viability of the planter. Any ratio above one denotes profitability, but anything above three is highly profitable for agricultural machines. The BCR obtained clearly indicates that profits from the planter exceed four times the cost incurred.
The presented technology of planting is especially advantageous for small and marginal farmers who cannot afford expensive mechanized equipment, because the cost of producing the planters was relatively low (₹10,000) and there is no need for fuel consumption, unlike with tractor-seeded planters. In addition, in the event that labour costs grow further in the future (for example, from ₹400 to ₹600 per working day), the costs of broadcasting seeds manually will also rise significantly, while the costs of operating the planters will only slightly increase. This makes the planter even more economical over time.From the findings, one can conclude that the designed manual maize planter is economically viable and also environmentally friendly and ergonomically efficient. This is due to the combination of cost-effectiveness, higher labour saving, ergonomic design, and economic viability of this tool.

CONCLUSION

Economic evaluation is performed by comparing the economic parameters of the manual maize planter operation with the economic parameters of broadcasting operations. The total running cost of the manual maize planter is ₹74.99 h^{-1}, including a fixed cost of ₹15.9 and a variable cost of ₹59.09 h^{-1}. The running cost of the manual maize planter operation is ₹499.33 ha^{-1}, which is much lower than ₹10,000 ha^{-1} needed in the case of broadcasting operations. Hence, there is an enormous reduction of 95% in the running costs, or ₹9,500.67 ha^{-1}. With 2.155 year payback period, the machine is highly economically feasible, which means that the initial cost will be paid back soon enough. Moreover, the machine is suitable for small and marginal farmers because of the low break-even point of 41.47 h yr^{-1}, in other words, only a few working hours per year are necessary to cover costs. Finally, the benefit-cost ratio of 4.638 clearly confirms that the income generated by using the machine is four times higher than the expenditure.

ACKNOWLEDGEMENT

Authors acknowledge Shobhit Institute of Engineering and Technology (Deemed-to-be University) Meerut, for using its facility to conduct the study.

REFERENCES

1. Adekanye, T. A. and Akande, Avoyunafa Mary., (2015), Development and Evaluation of a Manual Multi - crop Planter for Peasant Farmers. Elixir Agriculture. pp. 35095-35101.
2. Ajay, A. and Ramireddy, K.V.S.(2024), Economic Evaluation of Twin Row Maize Planter: A Cost-Benefit Analysis. *Environment and Ecology.,*42(1): 34-38.

3. Beg, A., Chauhan, N.S. and Patel, L.(2026). Economic Evaluation of a Self Propelled Planter Equipped with an Electronic Seed Metering System for Blackgram Cultivation, *Archives of Current Research International*, 25(12): 318-326.
4. Dikkar, P.M., dsouza, P.M., Moses, S.C., Aalam, R.N., and Kumar, S., (2024), Comparative cost analysis of conventional and various Garlic planting machinery. *International Journal of Research in Agronomy*., 7(4): 326-329.
5. Inthiyaz, M., Mishra, J., Mohanty, S.K., Pradhan, P.L., and Behera, D., (2021), Ergonomics of manual transplanting operations with female workers in eastern India. *Journal of Ergonomics*., 11(3), 282.
6. Jyotsna, N., Dipin, W., Telem, R.S., Donbiaksiam, T., and Thokchom, R. (2025), Optimizing minimum tillage technique and economic evaluation for field pea production in rice fallow lands in Manipur. *International Journal of Research in Agronomy*., 8(9): 418-422.
7. Khurdal, J.K., Bastewad, T.B., Phalphale, K.B., Pawase, P.P., Nalawade, S.M., Bhangare, S.C., Sapkale, P.R., and Solanke, A.V. (2024), Performance evaluation of tractor operated two row forward reverse rotavator for sugarcane crop. *International Journal of Research in Agronomy*., 7(1): 193–196.
8. Kirkhorn, S.R., Earle-Richardson, G., and Banks, R.J., (2010), Ergonomic risks and musculoskeletal disorders in production agriculture: Recommendations for effective research to practice. *Journal of Agromedicine.*, 15(3): 281–299.
9. Omara, P., Aula, L., Raun, B., Taylor, R., Koller, A., Lam, E., Ringer,J., Mullock, J., Dhital, S., Macnack, N. (2016). Hand planter for maize (Zea mays L.) in the developing world. *Journal of Plant Nutrition*, 39(9), 1233–1239.
10. Pakhare, M.M., Gujar, S.S., and Thakare, S.H., (2019), Techno-economic performance evaluation of small stractor operated folding type stubble collector. *International Journal of Chemical Studies.,*7(4): 849-852.
11. Rathod, S.N., Kushwaha, H.L., Kumar, A., Khura, T.P., Kumar, R., Dass, A., Chakraborty, D., Sarkar, S.K., K.R.A., Malkani, P., Gaddamwar, R., B.S.M., and Kumar, P., (2024), Comparative Analysis on Cost-Economics Evaluation of Robotic Tiller-Planter against Conventional Tillage and Planting Operations. *International Journal of Environment and Climate Change.,*14(1): 433-442.
12. Sari, A.D., Pusfitasari, N. and Rahma, R.(2013), Design and Evaluation New Rice Planter Tool without Mechanical Engine for Improving Conventional Farmer's Posture as Revival of Agriculture's Indonesia. *Advanced Engineering Forum.,* 10: 116-121.
13. Sheahan, P.J., Cashaback, J.G.A., and Fischer, S.L., (2017). Evaluating the ergonomic benefit of a wrist brace on wrist posture, muscle activity, rotational stiffness, and peak shovel-ground impact force during a simulated tree-planting task. *Human Factors: The Journal of the Human Factors and Ergonomics Society.,*59(6): 911-924.
14. Shockley,J.M., Dhilon, C.R., and Shearer, S.A. (2019), An economic feasibility assessment of autonomous field machinery in grain crop production. *Precision Agriculture.,* 20(5), 1068–1085.
15. Tiwari, P.S., Pandey, M.M., Gite, L.P., and Shrivastava, A.K., (2014), An ergonomic intervention in operation of a rotary maize sheller. *The Indian Journal of Agricultural Sciences.,*84(7): 791-795.