Environment and Ecology 42 (1) : 34—38, January—March 2024
Article DOI: https://doi.org/10.60151/envec/INRN7746
ISSN 0970-0420

# Economic Evaluation of Twin Row Maize Planter: A Cost-Benefit Analysis

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Received 25 July 2023, Accepted 22 November 2023, Published on 31 January 2024

## ABSTRACT

The adoption of innovative agricultural technologies plays a crucial role improving farm productivity and overall economic outcomes. This research article aims to evaluate the economic viability of twin row maize planters compared to conventional single-row planters. The study assesses the economic benefits, costs and profitability associated with the adoption of twin row planting in maize cultivation. The analysis incorporates factors such as yields improvement, input savings, labor requirements, and machinery costs, providing valuable insights for farmers. Annual utility of mini tractor and the machine was considered as 1000 and 200 hrs respectively. Field efficiency of developed twin-row planter at 1.5 to 2.5 $kmh^{-1}$ speed of operation was 76.9 to 87% respectively. The payback period calculated on year basis for planter was 1.78 years. Cost of operation by twin row maize planter can save up to 20% as compared to the traditional methods.

**Keywords** Twin row, Planter, Fixed cost, Variable costs, Payback period, Break-even point.

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## INTRODUCTION

Mechanization technologies keep changing with industrial growth of the country and socio-economic advancement of the farmer. In highly industrialized nations, a significant socio-economic challenge arises from the declined interest of landowners in agriculture and the scarcity of available agricultural labor for field operations.

The planting method plays important role in enhancing the crop for better establishment under a set of growing conditions. Maize seed was sown by different methods i.e, seed dropping behind a plough, dibbling, zero till drill, ridge planting and furrow planting. An alternate approach in maize seed sowing is twin-row planters. Some researchers (Balem *et al.* 2014) studied the conventional and twin-row spacing methods and concluded that the spacing of twin-row leads to an increase in the average maize yield and better growth than the conventional spacing. Twin-row was more consistent with herbicide resistant corn rather than conventional seed spacing. Twin-rows offer better Photosynthetically Active Radiation (PAR), and improve aeration which increases crop and root growth (Robles *et al.* 2012). Furthermore, a quicker canopy leads to fewer weeds and the humidity in the soil is conserved.

Agriculture sector is under increasing pressure to sustainably produce higher yields with less inputs, due to declining land and water, increasing world population. Sowing techniques and type of seeding machines play an important role in seed placement and seedling emergence which ultimately effect the crop growth and yield (Kumar *et al.* 2013). In highly mechanized production systems, the expenditure on machinery represents the primary cost component in agriculture. Additionally, over the past years, the utilization of high-power machines, advanced technologies increased expenses for spare parts and repairs as well as higher fuel consumption. This cumulative effect has led to a significant surge in machinery cost. Many engineering and economic methodological approaches have been implemented to calculate machinery use and cost, but they are almost confined in scientific and technical documentations making it difficult for a farmer to apply these approaches for deciding on buying, leasing or sharing agricultural machinery (Sopegno *et al.* 2016).

## MATERIALS AND METHODS

### Twin-row maize planter

A mini tractor drawn twin-row maize planter was designed and developed at Department of Farm Machinery and Power Engineering, Dr NTR College of Agricultural Engineering, ANGRAU, Bapatla. Four furrow openers made of mild steel were provided. The shaft of the seed metering device has a square section with a length of the shaft was 120 cm it was attached with at each end. The roller-type metering device is made up of nylon with a diameter of 12 cm and a width of about 5.5 cm. It has 5 cells on its periphery with an alternating pattern on both sides. An amount of Rs 10000 /- were spent for development for the machine. The specifications twin-row maize planter (Fig. 1) is shown in Table 1.

**Table 1.** Specifications of twin-row maize planter.

| Particulars | Specifications |
|---|---|
| Overall dimensions (L×*B*× *H*) | 1400 × 650 × 450 *mm* |
| Source of power | 18.5 hp tractor |
| Twin-row spacing, mm | 200 |
| Plant spacing in rows, mm | 200 |
| Types of seed metering mechanism | Roller type metering mechanism |
| Power transmission chain and sprocket | Chain and sprocket |

### Performance evaluation of twin-row planter

A mini tractor drawn twin-row planter was developed and performance was evaluated for maize crop. Two metering mechanisms namely roller type and cup type metering were selected and suitable seed boxes for each metering mechanism were developed and evaluated in the laboratory and field conditions. Four forward speeds (10,15,20 and 25 rpm) were selected to evaluate in the laboratory conditions. Parameters like seed spacing, missing and multiple indexes were analyzed. Laboratory results shows seed to seed spacing with cup type metering was 9.5 to 16 cm and with roller type metering was 11 to 20 cm at 10 to 25 rpm belt operational speed respectively. Missing index was 11.1 to 17.1% for cup type and 2.28 to 15.29% for roller type metering system. Based on laboratory results roller type metering was selected. The spacing between twin-rows was 20 cm. Results obtained from field conditions was seed spacing 20 cm was occurred at operating speed of 2.5 $kmh^{-1}$. Missing index was 10.44 to 27% with an operational speed of 1.5 to 2.5 $kmh^{-1}$. Field efficiency of developed twin-row planter at 1.5 to 2.5 $kmh^{-1}$ speed of operation was 76.9 to

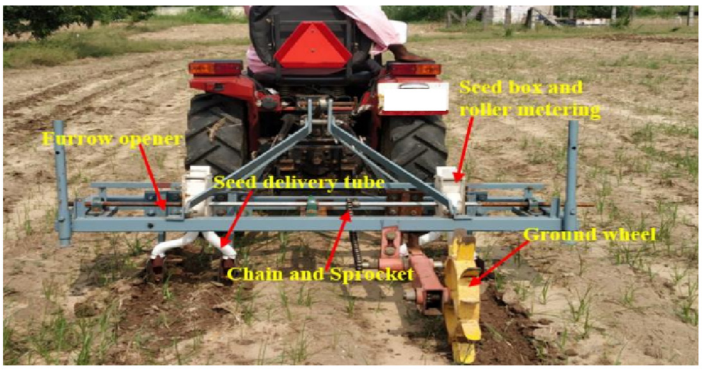


**Fig. 1.** Developed twin-row maize planter.

87% respectively.

**Economic evaluation of twin row maize planter**

The developed twin-row maize planter was designed by considering the initial cost as well as the operating cost of the implement. Total cost of a field operation it includes the implement rent, tractor rent and wages for labor. Implement and tractor costs are divided into two categories as fixed costs and operating cost (Mehta *et al.* 2019). The total cost of planting was determined based on fixed cost and variable cost (IS: 1964-1979). Fixed cost includes depreciation, interest, insurance, taxes and shelter whereas variable cost incudes repair and maintenance, fuel consumption, labour cost.

**Fixed cost**

***Depreciation***

Depreciation is the reduction in value of a machine with passage of the time (Kepner *et al.* 1987). There are four methods of determining depreciation cost and all the methods have their own merits and demerits. However, straight line method is the most preferred method of determining the depreciation cost of the machinery. In straight line method, the amount of depreciation cost is constant throughout the useful life of the machine (Singh 2017).

It is determined as :

$$\text{Depreciation (D)} = \frac{C\text{-}S}{L \times H}$$

C= Initial cost of machine, Rs/-

S= Salvage value of the machine, Rs/- (It is considered as 10% of initial cost of machine)

L= Useful life of machine, years

H= Annual use of machine, h/year

***Interest***

It is also referred as opportunity cost and is proportional to the remaining value of the machinery. The interest rate varies from, but usually will be in the range of 9 to 12%. The following equation is used for computing the interest amount on hours basis.

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

i= Annual rate of interest, %

C= Initial cost of machine, Rs/-

S= Salvage value of the machine, Rs/-

H= Annual use of machine, h/year

***Taxes, insurance and shelter***

In order to determine the cost towards insurance, taxes, and shelter an amount equivalent to 3% 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.

$$\text{Taxes, insurance and shelter} = \frac{C}{H} \times \frac{3}{100}$$

C= Initial cost of machine, Rs/-

H= Annual use of machine, h/year

**Total fixed cost** = Sum of the cost involved as depreciation, interest, insurance, taxes and shelter charge.

**Variable cost**

Variable cost is also referred as direct cost. Cost of operation varies directly with the use and has relation to the volume of machine output. It includes the fuel cost, lubrication, repair and maintenance, and wages (Singh 2017).

***Fuel cost***

The fuel cost is calculated based on the tractors' actual fuel consumption. Fuel cost per hour = Fuel consumption for the operation × Cost of fuel per liter

***Lubrication cost***

Lubricants and engine oils cost was calculated at 30 % of fuel consumption cost.

***Repair and maintenance costs***

Repair and maintenance costs vary from 5 to 10 % of the machine initial cost each year. It is usually charged at 6% per annum.

***labor cost***

It was assumed that labor cost was Rs 400 for labor a day. Total working hours should be considered as 8 hrs in a day.

**Breakeven analysis**

Breakeven analysis, also referred as point of no profit-loss is performed to asses the volume of work at a given price that is necessary to meet out all the costs. The breakeven point is the intersection of the lines at which the line of total cost and the line of total income. The volume of work greater than this would generate profit and vice-versa. The breakeven point can be determined using the following equation.

$$\text{Breakeven point (BEP)} = \frac{FC}{CHC - C}$$

Where, BEP = Breakeven point, h/year

FC = Annual fixed cost, Rs/year

C = Operating cost, Rs/h

CHC = Custom hiring charges, Rs/h

**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 200 hrs respectively.

**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 (Venkat *et al.* 2021).

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

Where, Average net annual benefit, Rs= (CHC – TOP) × Annual utility
CHC = Custom hiring charge, Rs/h = (25 % over total cost of operation Rs/h)
TOP = Total operating cost, Rs/h

## RESULTS AND DISCUSSION

From actual field conditions field capacity of developed machine was 0.2 ha/h with a forward speed of 2.5 km/h. Field efficiency of developed twin-row planter at 2.5 km/h speed of operation was 87%. Working width of the twin-row maize planter was 1.3 m and spacing between twin-rows are 20 cm, while the distance between two sets of twin rows is 50 cm.

**Cost determination of mini-tractor**

Life and annual utility and of tractor were considered as 10 years and 1000 hrs per year respectively. Fixed cost and variable costs of a tractor were calculated as 52.5 Rs/h and 356 Rs/h. The operating cost of the tractor obtained was 409.44 Rs/h (Table 2).

**Cost determination of twin-row maize planter**

Life and annual utility and of tractor were considered

**Table 2.** Mathematical calculations for cost estimation of tractor and twin-row planter.

| Particulars | | Tractor | Twin-row planter |
|---|---|---|---|
| **Assumptions** | | | |
| 1 | Service life (year) | 10 | 10 |
| 2 | Working hour per year | 1000 | 200 |
| Fixed cost (Rs/hr) | | | |
| 1 | Depreciation | 27 | 4.05 |
| 2 | Interest | 16.5 | 2.47 |
| 3 | Insurance, taxes and shelter | 9 | 1.35 |
| | **Total fixed cost** | **52.5** | **7.87** |
| **Variable cost (Rs/hr)** | | | |
| 1 | Fuel cost | 199.19 | 0 |
| 2 | Lubrication cost | 59.75 | 0 |
| 3 | Operators wage | 50 | |
| 4 | Repair and maintaince | 48 | 8 |
| | **Total variable cost** | **356.94** | **8** |
| **Total** | | **409.44** | **15.87** |
| **Total cost of operation Rs/h** | | | **425.31** |

as 10 years and 200 hrs per year respectively. Fixed cost and variable costs of a tractor were calculated as 7.87 Rs/h and 8 Rs/h. The operating cost of the tractor obtained was 15.78 Rs/h (Table 2).

**Combined cost of twin-row planter and tractor**

Total fixed cost is the summation of fixed costs of tractor and machinery which is obtained as 85,800 Rs/year. The total variable cost of the combination was calculated as 364.94 Rs/h. The total operating cost of tractor and machinery combined was calculated as 425.31 Rs/h. But in existing manual methods it requires 2400 Rs/ha for sowing, with that of mini tractor drawn twin-row maize planter 1933.18 /ha to complete the operation. By adopting this machinery farmers can save 490 Rs/ha over one hectare of land.

**Payback period**

$$\text{Payback period} = \frac{40000}{22442} = 1.78 \text{ years}$$

## CONCLUSION

Twin-row maize planter offer numerous benefits compared to traditional manual methods of seed sowing, including improved seed placement accuracy, reduce seed wastage, and enhanced crop uniformity. By minimizing seed wastage and ensuring precise seed spacing and depth, it enables farmers to optimize their used of seeds, resulting cost savings. Additionally, the reduction in labor required for manual seed sowing allows farmers to allocate their resources more efficiently. The payback period calculated on year basis for planter was 1.78 years. Cost of operation by twin row maize planter can save up to 20% as compared to the traditional methods.

## ACKNOWLEDGMENT

Authors are thankful to Department of Farm machinery and power engineering, Dr. NTR College of Agricultural Engineeering, Bapatla for providing necessary facilities at workshop.

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