



Performance Evaluation of Manually Operated Ridge Vegetable Planter for Okra

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Authors' contributions

This work was carried out in collaboration between all authors. Author VK designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors VR and MJ managed the analyses of the study. Authors AK, SK and Naresh managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A manual ridge vegetable planter was developed for the sowing of vegetable crops on ridges. It consisted of seed metering mechanism- an acrylonitrile butadiene styrene polymer seed-metering roller having cells on its periphery, mainframe, speed reduction unit, handle, seed tube and tyne. Roller tyres were mounted on two forks, which were attached to the mainframe. Seed metering mechanism received power from rear roller tyre. Seed tube with conical seed capturing funnel was provided to guide seed to the boot of tyne. Tyne was mounted on tyne bolt for intra-row spacing adjustment. At forward speed of travel 1.60 km h⁻¹, and at optimum 7 mm cell and 1.40 km h⁻¹ peripheral speed of seed roller, it was evaluated for okra planting. Effective field capacity of the planter was 0.046 ha h⁻¹ with field efficiency of 86.79%. The draft requirement of the planter was 4.4 kgf. Planting of okra seeds by developed planter resulted into net saving of Rs. 813 per hectare. The payback period and benefit cost ratio of the planter was 2.01 years and 1.56, respectively. The labour requirements with the developed planter were 21.73 man-hours per hectare saving 51.1% time of planting in one hectare area in comparisons to manual dibbling.

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1. INTRODUCTION

India occupies the first position in the production of okra, commonly known as ladyfinger, in the world. It was sown in 5.33 lacs hectares leading to production of 6.3 million tons [1] minting a world share of 66.0%. However, productivity is low in comparison to other countries. One of the major constraint in increasing productivity is that the planting operations are one of the least mechanized operations in farm operations owing 29% mechanization only [2]. Manual dibbling of seeds on ridges leads to uneven spatial distribution of seeds in horizontal as well as vertical dimensions. The chances of putting more than one seed per hill are also high. The seeds are the critical component in agriculture and its efficacy determines the overall agricultural productivity. Any undesired seed in a hill results into financial burden to the farmer. High yielding crops and hybrid varieties are slowly becoming popular among farmers. These crop varieties helps in advancing of Indian agriculture, but high cost of these seeds impose a limit in their adoptability on wide scale. This, in turn, has led to the improvement of existing farm machines and development of efficient farm equipment for highly efficient use of available seeds for sustainable development of Indian agriculture. In addition, it is very important for peasant farmers to use their time for multiplying their productivity in farm jobs, which does not require much human power, to squeeze out every drop of their financial investments. The farmer needs to be in continuous stooping position while planting of seeds on ridges, which results in serious backache and other health problems [3]. This also limits the size of field that can be planted manually.

In recent years, different scientists evaluated prototypes to lessen the human drudgery in planting operation and to increase the farm productivity. A two-row okra planter developed from locally available materials was able to effectively place maximum of two seeds per hill [4]. It had field capacity of 0.36 ha hr^{-1} with average field efficiency of 71.75%. For digging and seeding for sowing on flat seedbed, a plunger flapper mechanism was used [5]. It has different sizes of cylindrical hole perpendicular to axis of seed plate, based on suitability for different crops such as okra, beet, pea, carrot, etc. It was quite successful in increasing the productivity in planting. Adisa and Braide [6]

developed a manually operated template row planter, which was able to plant on both ridged seedbed and flat seedbed. It had an average field capacity of 0.2 ha h^{-1} . The draft requirement of the machine was 85 N at average travel speed of 2.16 km h^{-1} . Adekanye [7] developed and evaluated a manual multi-crop hand push planter. The seed metering mechanism of the planter consisted of plastic roller with cells on its periphery. The planter was used for three crops- cowpea, maize and soybean on flat seedbed. It had 76.3% field efficiency and 0.39 ha h^{-1} field capacity. The planter was able to meter 2-3 seeds per hill.

The present study was aimed to assess field performance of a manually operated ridge vegetable planter and its economic evaluation in comparison to traditional practice of okra planting.

2. MATERIALS AND METHODS

2.1 Manual Ridge Vegetable Planter

The manual ridge vegetable planter (Fig. 1) consisted of units, namely, seed metering unit, mainframe, speed reduction unit, handle, seed tube and tyne. The planter was developed to meter the seed and placement of seed at desired depth and spacing on ridged seedbed. Roller tyres were mounted on two forks. Forks were attached to the main frame. Seed metering mechanism received power from rear roller tyre. Seed tube with conical seed capturing funnel were provided to guide seed to the boot of tyne. Tyne was mounted on tyne bolt for intra-row spacing adjustment.

2.2 Field Evaluation of Developed Prototype Planter

The field experiments for the performance evaluation of the developed planter were conducted in farmer's field in village- Dabra, Hisar. Each treatment was replicated thrice.

The following indicators of performance of bed planter were calculated using the observed data in the field:

1. Actual field Capacity, ha h^{-1}
2. Field efficiency, %
3. Row to row spacing, mm
4. Depth of seed placement, mm
5. Draft required to operate the planter,
6. Field machine index

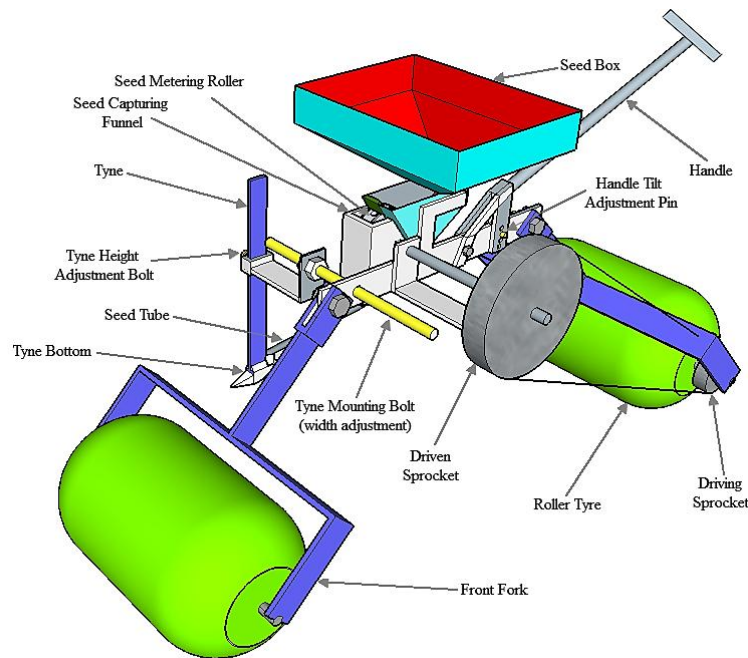


Fig. 1. The design of the ridge vegetable planter

2.2.1 Effective field capacity

It is an indicator of how fast an area can be planted with the desired crop. The actual operating time along with time lost for every event such as turning at field ends, re-filling seed in seed box and machine adjustments are recorded in the field test area. The effective field capacity of the machine is calculated as follows:

$$EFC = \frac{A}{T_p + T_1}$$

Where, EFC = Effective field capacity, ha h⁻¹
 A = Area covered, ha
 T_P = Productive time, h
 T₁ = Total non-productive time, h

(Time lost turning at field ends, re-filling seed in seed box and machine adjustments).

2.2.2 Field efficiency

It was calculated from the field test data as follows:

$$E_f = \frac{EFC}{C_T} \times 100$$

Where, E_f = Field efficiency, %

$$C_T = \text{Theoretical field capacity, ha h}^{-1} \\ = \frac{W \times S}{10}$$

W = Average working width of the prototype planter, m

S = Average speed of travel, km h⁻¹

EFC = Effective field capacity, ha h⁻¹

2.2.3 Row to row spacing

Row to row spacing of okra was taken as 400 mm [8].

2.2.4 Depth of sowing

The depth of seed sown by the planter was measured randomly at five locations in each replication at the time of planting.

2.2.5 Draft required to operate the planter

Draft is an important parameter for any agricultural machine. Draft is measured by towing the prototype with an electronic dynamometer. It is reported as average of five readings taken.

2.2.6 Field machine index

The field machine index is calculated by using the following formula, which indicates the

influence of field geometry on working capacity of the machine:

$$FMI = \frac{T_o}{T_p + T_t} \times 100$$

Where, FMI= Field machine index, %
 T_o = Theoretical field time, min plot⁻¹
 T_p = Total productive time, min plot⁻¹
 T_t = Total turning time, min plot⁻¹

2.2.7 Crop response

The following parameters indicates crop response:

- Plant stand per meter of row length
- Plant height, mm
- Mortality, %

2.2.8 Plant stand per meter of row length

The plant stand per meter row length of okra crop in the experimental field (Fig. 2) was counted seven days after sowing for okra crop. The observations were taken for ten meter row length for okra.



Fig. 2. Prototype planter in the farmer's field

2.2.9 Plant height

Plant height of ten randomly selected okra plants was taken after 7 days of planting (Fig. 3). Plant height was recorded from base of the stem to top leaf of plant for okra.

2.2.10 Mortality

Mortality is a measure of the number of deaths of plants in a particular population, scaled to the size of that population, per unit of time. Mortality rate is typically expressed in units of deaths per 100 plants.

3. ECONOMICS OF VEGETABLE PLANTER IN COMPARISON TO CONVENTIONAL PRACTICE

The economics of the developed prototype planter will be helpful in decision making of use of the new planter vs. conventional practice for individual farmer. There are two components of the cost of a machine namely,

- Fixed cost and
- Variable cost.

Fixed cost includes depreciation, interest, insurances, taxes and housing. Variable cost includes fuel, lubricates, operator's wages and repair and maintenance cost. Cost of operation was compared with conventional practice.

3.1 Cost of Operation

The total cost of operation is determined as the sum of the fixed and variable cost. The total cost of operation per hour of the planter was computed. The total cost of operation of the planter was determined by adding the hourly cost of operation of the planter and labour charges and expressed in rupees per hour. It was converted into area basis by multiplying it with the effective field capacity of the machine and expressed in rupees per hectare.

3.1.1 Fixed cost

3.1.1.1 Depreciation

This cost reflected the reduction in value of machine with use (wear) and time. The straight-line method was used to calculate the depreciation:

$$D = \frac{P - S}{L \times H}$$

Where, D = Depreciation, Rs h⁻¹
 P = Purchase price of the machine (Rs)
 S = Salvage value of the machine (taken as 10% of purchase price)
 L = Useful life of the machine in year
 H = Annual use, h year⁻¹



Fig. 3. Okra crop after 7 days of planting

3.1.1.2 Interest

Annual charges of interest were calculated based on the actual rate of interest payable. It was taken at the interest rate of 12% of average purchase price of the machine.

$$I = \frac{P + S}{2 \times H} \times \frac{i}{100}$$

Where, I = Annual charges of interest (Rs h⁻¹)
i = Interest rate per year, %

3.1.1.3 Insurances, taxes and housing cost

It was calculated as 3% of the average purchase price of the machine per year.

3.1.2 Variable cost

Variable cost is total of repair, maintenance and labour charges.

3.1.2.1 Repair and maintenance

Repair and maintenance expenditure is necessary to keep the machine in proper operating condition due to wear, part failure, replacement of parts etc. It was computed at the rate of 7% of purchase price for the machine per year.

3.1.2.2 Labour charges

Labour charges are the charges that are paid to the labours based on the working 8 h per day in the field. The labour charged Rs. 400 during sowing season.

The cost of operation was determined as sum of the fixed and variable cost. The cost of manual planting was calculated by taking into account the cost of man-hour required for planting. The man-hour requirement for planting was recorded on the test plot. The manual planting on ridged seedbed was done by farm labours. The cost of operation of manual planting was added to determine the total cost on ridged bed. The costs thus observed under the planter planting and manual planting was compared.

3.2 Payback Period

It is the number of year it would take for an investment to return its original cost through the annual cash revenues it generates, if the net cash revenues are constant each year. The payback period is calculated following equation:

$$P = \frac{I}{E}$$

Where, P = Payback period, years
I = Amount of investment, Rs
E = Expected annual net revenue, Rs

3.3 Benefit-cost Ratio

It is the ratio of annual benefit to annual cost. The benefit-cost ratio must be unity or more for a project investment to be considered worthwhile. This technique also ranks the project investments for selection. The ratio of unity indicates the coverage of costs without any surplus benefits. However, usually the ratio has to be more than unity in order to provide some additional return over the costs for clear decision.

$$\text{Benefit - Cost Ratio} = \frac{\text{Gross Return (Rs ha}^{-1}\text{)}}{\text{Cost of operation (Rs ha}^{-1}\text{)}}$$

4. RESULTS AND DISCUSSION

4.1 Performance Evaluation of Vegetable Planter for Okra Planting

The developed vegetable planter was tested in farmer's field at village- Dabra, Hisar (Haryana). The planter was operated on ridged seedbed (Fig. 4) by the operator at travel speed of 1.6 kmh⁻¹.

The evaluation was done at the optimized values of the variables of the machine. The sandy loam soil of the test field had an average moisture content of 1.04% (dry basis) and bulk

density of 1.57 g cm^{-3} . The field was irrigated after planting of seeds. The performance of the developed vegetable planter is given in Table 1.

The field capacity of the developed planter was 0.046 ha h^{-1} with field efficiency of 86.79% at travel speed of 1.6 km h^{-1} . Field machine index of planter was 91.68%. High field efficiency is obtained due to lesser time loss in turning at the ends of ridges. The operator need to push handle vertically downward to lift front roller tyre above ground and then simultaneously rotating the planter in horizontal plane, in the same position at centre point of rear roller tyre. The planter is lightweight so it was manually lifted while crossing at furrow. The average draft requirement of planter at travel speed of 1.6 km h^{-1} was 4.4 kgf, which was less than the design limits of push strengths of 4.5 kgf for male agricultural workers [9]. Dineshkumar and Jaimin [10] reported 0.132 ha h^{-1} actual field capacity, 79.52% field efficiency and 8.8 kgf average draft requirement for single row manual cotton planter at travel speed of 1.62 km h^{-1} . Singh [11] reported the average field capacity of 0.11 ha h^{-1} with the average field efficiency 80.98% for continuous operation of the two row self-propelled multicrop planter at average forward travel speed of 1.36 km h^{-1} . It was used for planting both maize and soybean. Adekanye [7] reported field efficiency and field capacity of 76.3% and 0.39 ha h^{-1} , respectively, for manual multicrop planter. Nirala [12] reported field capacity of 0.23 ha h^{-1} and field efficiency of 51.1% for bullock drawn multicrop inclined plate planter.

4.3 Depth of Seed Placement

The average value of depth of seed placement on ridges was 22.86 mm with coefficient of

variation as 3.35%. It was slightly lower than a sowing depth of 25 mm as recommended by Anderson [13]. Higher seed depth can be achieved by lowering the tyne. Low variation in depth of seed placement is attributed to the roller tyre. Roller tyre keeps the planter stable while operating. It consider large surface area of top layer of soil as its reference surface on which it travel. Large surface area has lower undulating reference surface for movement of roller tyres.

4.4 Crop Response

Crop response was recorded after 7 days of sowing operation in the testing field. It is depicted in Table 2.

4.5 Economic Evaluation of the Developed Vegetable Planter

The calculation of the operating costs including fixed and variable costs was made for the developed vegetable planter. The total operating cost of the planter was Rs 70.48 per hour (Rs 1409 ha^{-1}). The comparative cost of operation of machine and manual digging is presented in Table 3.

It is evident from the Table 3, that sowing operation by developed planter results into net saving of Rs. 813 per hectare. The labour requirements with the developed planter and manual planting were 21.73 man-hours per hectare and 44.44 man-hours per hectare, respectively. Thus, it saved 51.1% time of planting in one-hectare area. Dineshkumar [10] reported 31.83% saving in time for single row cotton planter as compared to manual dibbling. The custom hiring fee of operation for developed vegetable planter was calculated as Rs 1416.56 h^{-1} .

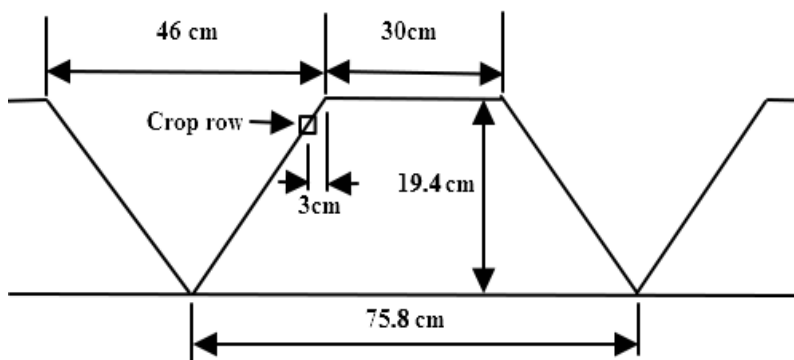


Fig. 4. Cross section of ridge

Table 1. Performance parameters of the prototype

S. No.	Parameter	Value
1.	Actual field capacity, ha h ⁻¹	0.046
2.	Theoretical field capacity, ha h ⁻¹	0.053
4.	Field efficiency, %	86.79
5.	Row to row spacing	
	Across ridges, cm	36
	Across furrows, cm	40
6.	Draft requirements, kgf	4.4
7.	Field machine index, %	91.68
8.	Labour requirement	1

Table 2. Crop response

Sr. No.	Property	Mean	Range	Coefficient of variation, %
1.	Plant stand per meter after 7 days	6.2	3–9	25.28
2.	Plant height after 7 days, mm	21.8	17–27	12.99
3.	Mortality, %	8.33	6–11	24.01

Table 3. Economic evaluation of the planter

S. No.	Parameter	For planter	Manual planting
1.	Total cost of operation, Rs h ⁻¹	70.48	–
2.	Total cost of operation, Rs ha ⁻¹	1409	2222
3.	Man-hours per hectare	21.73	44.44
3.	Net Saving in cost of operation, Rs ha ⁻¹	813	–
4.	Average net annual profit in cost of operation, Rs	3964	–
5.	Annual fixed cost, Rs year ⁻¹	1488	–
6.	Payback period in year	2.01	–
7.	Benefit cost ratio	1.56	–
8.	Break-even point, h year ⁻¹	37.53	–

5. CONCLUSION

The field capacity of the developed planter was 0.046 ha h⁻¹ with field efficiency of 86.79% at a forward travel speed of 1.6 km h⁻¹. Field machine index of planter was 91.68%. The average value of depth of seed placements on ridges was 22.86 mm with coefficient of variation as 3.35%. The total operating cost of the planter was Rs 70.48 per hour (Rs 1409 ha⁻¹). Planting of seeds by the developed planter resulted into net saving of Rs. 813 per hectare as compared to manual planting. The payback period and benefit cost ratio of the planter was 2.01 years and 1.56, respectively. The labor requirements with the developed planter were 21.73 man-hours per hectare saving 51.1% time of sowing in one hectare area as compared to manual dibbling.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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