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Performance evaluation of manually operated single row cotton planter

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Abstract
A proper placement of seed in field is most important operation in order to obtain optimum yield of crop. In India about 75 % of the land holders are small and marginal land holding capacity. Considering the limitations due to costly seed, traditional method of manual dibbling, labour shortage and small marginal land holding pattern there is need of small manual planter for small and marginal land holders. Cotton, the white gold, is the king of textile, fibers and it is an important worldwide cash crop. The sowing of cotton is labour intensive as its planting requires 3-4 man days/ha. In view of the above, the single row cotton planter was tested in laboratory as well as in field as per IS code: 6316-1993 with specific objectives. The cost of planting cotton by manually method is approximately 600 to 700 Rs/ha, whereas the cost by this machine is 470 Rs/ha. The field evaluation of manually cotton planter was done at speed of 1.72 km/hr with field capacity of 0.170 ha/hr and field efficiency of 82.49 %. The seed uniformity of cotton planter was observed higher as compared to manual sowing. The average labour requirement for sowing cotton in manually operated cotton planter was 6.82 man hr/ha.

Keywords: Cotton, sowing method, single row cotton planter, performance evaluation

Introduction
Cotton (Gossypium spp.), "the king of fibre" and "white gold" is one of the most important crops commercially grown over 111 countries throughout the world. India ranks first in the world under cotton cultivation and accounts for 11 million ha area (Anonymous, 2011) [1]. Cotton accounts for around 80 per cent of the total fibre consumption in textile sector, which accounts nearly 30 per cent of India's industrial. In India, there is diverse farm mechanization scenario in country due to varied size of the farm holdings and socio-economic disparities. Most of farmers in India are small and marginal land holder hence, tractor drawn planter have been eliminated acceptability.

Sowing is one of the most important operations in raising crops. Timely sowing has a dominant effect on germination of seed, plant growth and also plant population in the field. Cotton planting is conventionally done by manual dibbling. The seeds are dibbled in lines at a depth of 30 mm with two seeds per hill maintaining the desired spacing between the rows and plants. The labour requirement for planting cotton is high (15 %) which is next to harvesting operation (44 %) (Vaiyapuri, 2004) [3]. This results higher cost of cultivation. Moreover, the traditional planting method is tedious, causing fatigue and backache due to the longer hours required for careful hand metering of seeds if crowding or bunching is to be avoided.

Major cotton growing states in India are Gujarat, Maharashtra, Andhra Pradesh, Punjab, Karnataka, Haryana, Madhya Pradesh, Rajasthan and Tamil Nadu. The major cotton growing districts in Gujarat are Surendranagar (4.482 lakh ha.), Rajkot (2.818 lakh ha.), Amreli (2.356 lakh ha.), Ahmedabad (1.852 lakh ha.), Vadodara (1.734 lakh ha.), Bharuch (1.294 lakh ha.), Junagadh (0.587 lakh ha.), Kheda (0.321 lakh ha.), etc. (http://www.cotcrop.gov.in/statistics.) [4]. Keeping the above fact in mind, the present study was undertaken with specific objectives to test the single row cotton planter as per IS Code: 6316-1993 and to find out cost of sowing.

Materials and Methods

Location of experiment

Field experiments were conducted on research plot of Research, Testing and Training Centre, Junagadh Agricultural University, Junagadh, during the academic year 2019-2020. Some laboratory experiments were conducted in the Department of Farm Machinery and Power Engineering.

Manually operated single row cotton planter has the following main components.

Seed drum

Seed drum was designed in such a way that it could hold sufficient quantity of seeds for a longer period of operation, to avoid refilling often. It rotates freely on the main axle during the operation.

Seed metering wheel

This is the most important part of the planter as it meters the seed. An appropriate size of hole was made on the metering wheel and the dimensions of hole were decided by considering the dimensions of coated cotton seeds. It was fabricated from M. S. flat having width and thickness 70 mm × 3 mm.

Metering wheel inserted into the seed drum and tightened to the axle by bolt and remains in stationary position during operation. Clearance between the metering wheel and the seed drum is very low therefore the diameter of metering wheel was taken slightly less than the diameter of seed drum for the free rotation of the seed drum. Seeds flowed out to the duckbill when the hole on metering wheel coincides with the hole on seed drum.

Supporting wheel

The diameter of supporting wheel was equal to the diameter of seed drum for proper contact between the outer periphery of the seed drum and soil. It was provided to control the depth of seed placement and to avoid the tilting of planter laterally. It was fabricated from M. S. flat having width and thickness 30 mm × 2 mm. The diameter of rim was kept 430 mm.

Duckbill

It opened the soil at proper time and places the seed at desired depth. Spring mechanism was provided to open and close the duckbill during operation. Three duckbills were mounted on the outer periphery of the seed drum at an equal distance of 450 mm. It was made up of G.I. Square pipe (25×2 mm) tapered along the length of 70 mm.

Press wheel

One press wheel was provided at the rear side of the planter just behind the seed drum. It was provided to compact the soil after the placement of seed. It was also used for transporting the planter from one place to another. It was made up of M.S. pipe of diameter 120 mm and width 200 mm having pipe thickness of 3mm.

Handle

A handle was provided for controlling the movement and applying force on cotton planter by the operator. The handle was fabricated from G.I. pipe of diameter 30 mm. The length was made adjustable and extended up to 250 mm extra according to the operator's height and comfort. The handle was ergonomically designed.

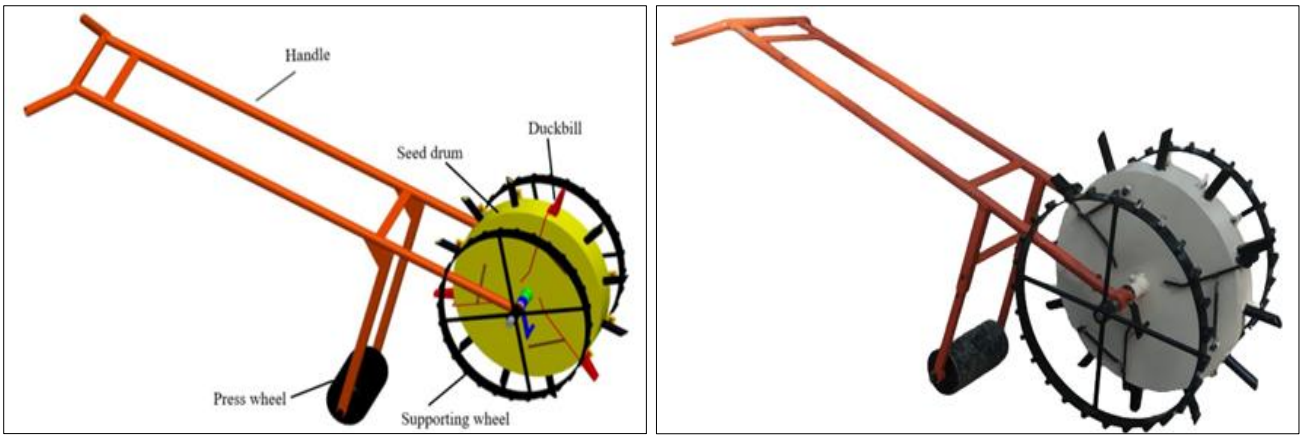

Fig 1: View of Developed planter

Performance evaluation of manually operated single row cotton planter

During its performance evaluation, its field capacity, efficiency, plant damage, energy consumption, power requirement speed of operation, cost of operation etc. were determined.

A. Laboratory test

The following tests shall be conducted in the laboratory:

a) Metering test

1. Calibration - To determine the seed dropping rates obtainable at different hopper capacity and settings when the machine is stationary.

2. Seed damage test - To determine if any mechanical damage is done to the seed during the calibration.

$$\text{Damage percentage (\%)} = \frac{\text{weight of damage seeds}}{\text{weight of total seed collected}} \times 100$$

b) Uniformity of Seeding -- To determine whether the drill is placing the speed uniformly or not. It was done by using the sand bed method.

B. Field test

Coefficient of uniformity

The spacing between two consecutive seeds was measured for a length of 10 m run in a row. The average value was found out and the coefficient of uniformity was calculated by following formula,

$$\text{Coefficient of uniformity (\%)} = \left(1 - \frac{\sum |x - \bar{X}|}{N\bar{X}}\right) \times 100$$

Depth of seed placement
The planter was operated in field under the good seed bed condition. Then the soil was removed carefully without disturbing the seed at several spots in each row. The depth of the seed below the soil surface was measured by depth gauge.

Operating speed
The operating speed was calculated for the planter by observing the productive time taken to travel 40 m length of plot with the help of stop watch.

(a) **(b)**

Plate 1: View of (a) Field operation and (b) calibration of developed planter

Theoretical field capacity
The rate of coverage of the machine based on 100 % of time at rated speed and covering 100 % of its rated width is known as theoretical field capacity.

$$\text{Theoretical field capacity (ha/h)} = \frac{\text{Width of coverage (m)x Speed (km/h)/}}{10}$$

Effective field capacity
The actual area covered with time including the time loss is known as actual or effective field capacity.

$$\text{Actual or Effective field capacity (ha/h)} = \frac{\text{Area of plot (ha)}}{\text{Time taken (h)}}$$

Field efficiency
Now, the field efficiency was calculated as follows

$$\text{Field efficiency (\%)} = \frac{\text{Actual field capacity(ha/h)}}{\text{Theoretical field capacity (ha/h)}} \text{ x } 100$$

Labour requirements
Number of persons required to operate the cotton planter was considered to calculate the total labour requirement.

Draft measurement
A spring type dynamometer (0-100 kg) was used to measure the draft required to operate the cotton planters. D = Draft (kg), P = Pull/Push (kg) and θ = angle with horizontal, (degree)

Draft is measured by using the formula:

$$D = P \cos\theta$$

Power developed by operator
Power developed by the planter was calculated by using the formula:

$$\text{Power (hp)} = \frac{\text{Draft (kg)}\times\text{Speed (m/s)}}{75}$$

Energy consumption
The cotton planter was operated by manually in field. The human energy utilized in mechanical sowing operation in the field for planter was evaluated as per described by Chaudhary *et al*. (2006) [2]. It was calculated by following formula:

$$E_m = 1.96\ N_m.\ T_m$$

Cost of operation
Cost analysis was made for estimating the cost of different operations. The fixed and variable costs were taken into consideration to estimate the cost of operations. Straight line method of cost analysis (to find depreciation cost) was adopted.

Results and discussions
Single row cotton planter was tested as per IS Code: 6316-1993 at research plot of Research, Testing and Training Centre, Junagadh Agricultural University, Junagadh in laboratory as well as field.

Table 1: Particulars Specifications/Results and Developed planter

S. No.	Particulars	Specifications/Results
		Developed planter
1	Power source and type of action	Manually operated (push type)
	Constructional details	
	Overall dimensions	
2	Length (mm)	1550

3	Width (mm)	420
4	Height (mm)	860
5	Weight (kg)	20
	Field details	
6	Area of plot	40 m X 25 m
7	Type of soil	Medium black soil
8	Bulk density of soil	1.20 g/cc
9	Moisture content of soil	19.10 %
	Crop parameters	
10	Crop	Cotton (Gossypium spp.)
11	Seed Type	Coated cotton seed
12	Seed rate	3 kg/ha
13	P – P spacing	45 cm
14	R – R spacing	120 cm

A. Laboratory test

Calibration

The planter was calibrated as per recommended seed rate of cotton i.e. 3.0 kg/ha. The calibrated seed rate was found as 2.8 kg/ha.

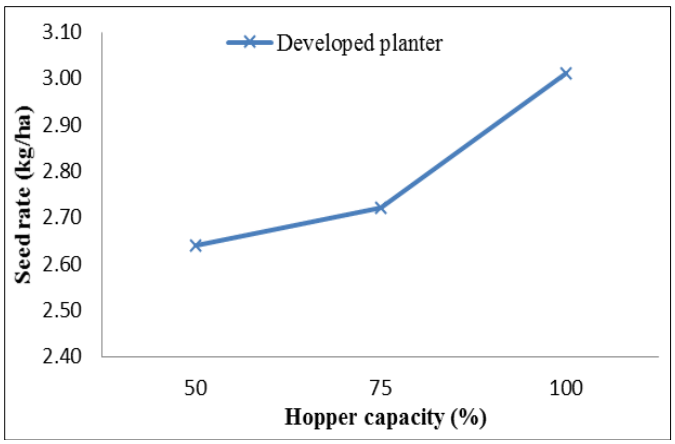

Fig 2: Graphical representation of seed rate at different hopper capacity

Seed damage test

The number of seeds with visible damage in sample was taken and mechanical damage was found as 6.18 %. This was due to the shearing of seed in between the seed drum and the metering wheel.

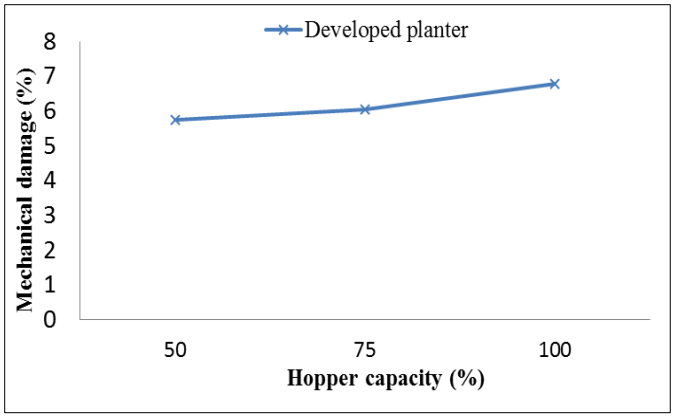

Fig 3: Graphical representation of seed damage at different hopper capacity

Seed uniformity test by sand bed method

The average distance between two seeds was found about 43 cm, which was near to the recommended (45 cm). The alignment of seeds was near to the straight line, which is harder to maintain in manual sowing.

B. Field test

Coefficient of uniformity

The coefficient of uniformity for developed planter was 91.69 to 93.23 % with an average of 92.26 %.

Depth of seed placement

Depth of seed placement by developed planter was measured as 4.7 cm in the field and the recommended depth is 4 to 6 cm.

Operating speed

Time was recorded to cover 40 m distance in each pass and average speed was calculated. The average speed of developed planter was observed as 1.72 km/h.

Theoretical field capacity

The theoretical field capacity of developed planter varied from 0.188 to 0.222 ha/h and the average was calculated as 0.206 ha/h.

Effective field capacity

The effective field capacity of developed planter varied from 0.160 to 0.182 and average was calculated as 0.170 ha/h.

Field efficiency

The average field efficiency of developed planter was 82.52 %, which is higher than the manually sowing and other manually operated cotton planters.

Labour requirements

One labour was sufficient to perform the sowing operation by the developed cotton planter. While in case of existing planters two labours were required to perform the sowing operation i.e. one for pulling the planter and another for helping him for showing direction of pulling, balancing and lifting the planter while turning. The average labour required for operating the developed planter was 6.82 man-h/ha, which is lower than other manually sowing methods.

Draft measurement

The average draft measured in developed planter was 12.72 kgf. In developed planter the draft was more because of its weight, which is heavier than other planters.

Power developed by operator

On the basis of draft, the average power required was worked out as 0.094 hp. The value lies within the working range of human being.

Energy consumption

The energy used by developed planter was less because only

one labour was required for operating the planter. The energy consumption was calculated as 11.4 MJ/ha.

Cost of operation

The cost of sowing of this planter for cotton was 37.25 Rs/h and 473.82 Rs/ha. The total operating cost of developed planter was low because of one labour requirement for sowing operation and also required less seed rate as compared to other planters.

Conclusions

From the testing and evaluation of cotton planter, following conclusions were emerged during the study.

1. The planter has simple mechanism and can be easily operated by the farmers.
2. The draft requirement of the planter was ranged from 10.32 to 13.48 kgf.
3. The effective field capacity of the planter was 0.170 ha/hr.
4. The field efficiency of planter was found as 82.52 %.
5. The cost of sowing of cotton by this machine was found low as compared to manual sowing.
6. The average power requirement was ranged from 0.083 to 0.10 hp and lies in the working range of human being.
7. All these tests indicate that the planter was easily pulled by a normal man.

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