Journal of Experimental Agriculture International

Volume 46, Issue 2, Page 68-77, 2024; Article no.JEAI.112021
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Performance Evaluation of Manual Seeder Machine for Precision Farming

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2024/v46i22309

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/112021

Original Research Article

Received: 24/11/2023
Accepted: 29/01/2024
Published: 05/02/2024

ABSTRACT

Proper placement of seeds in the field is the most important operation to obtain an optimum yield of the crop. In India, about 75% of the landholders are small and have marginal land-holding capacity. Considering the limitations due to costly seed, the traditional method of manual dibbling, labor shortage, and small marginal land holding pattern there is a need for small manual planters for small and marginal landholders. Cotton, the white gold, is the king of textile, fibers and it is an important worldwide cash crop. The sowing of cotton is labor intensive as its planting requires 3-4 man-days/ha. Because of the above, the manual seeder was tested in the laboratory as well as in

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the field as per IS code: 6316-1993 with specific objectives. Laboratory analysis of manual seeder as seed rate (2.85 kg/ha and 2.88 kg/ha), seed damage (7.84% and 7.74%), and seed uniformity (62 cm and 64 cm) of cotton and castor crop respectively. Field analysis of manual seeder as coefficient of uniformity (91.63% and 93.23%), depth of seed placement (5.7 cm and 5.9 cm), speed of operation (1.82 km/h 1.84 km/h), theoretical field capacity (0.93 ha/h and 0.93 ha/h), effective field capacity (0.166 ha/h 0.171 ha/h), field efficiency (86.01% and 88.60%), draft (9.54 kgf and 10.46 kgf), energy consumption (10.93 MJ/ha and 10.04 MJ/ha) and cost of operation (440 Rs/ha and 445 Rs/ha) of cotton and castor crop respectively.

Keywords: Precision seeder; precision sowing method; single-row cotton seeder.

1. INTRODUCTION

"Agricultural mechanization entails the use of various power sources as well as improved farm tools and equipment to reduce human and animal drudgery, improve cropping intensity, precision, and timeliness of crop input utilization, and reduce losses at various stages of crop production" [1]. "India has a huge amount of agricultural land area, so massive residues are produced here" [2]. "India ranks second worldwide in horticulture production. The scenario of horticultural crops in India has become very encouraging" [3]. "Now a day most of the operations in agriculture are being performed by machines. This reduces the human efforts which have been the principal motivating force in mechanization" [4].

"Sowing is one of the most important operations for any crop. It effects on rising of crops, germination of seed, plant growth, plant population, and crop yield in the field. The labor requirement for planting cotton manually is high (15%), which is next to harvesting operation (44%)" Vaiyapuri K. [5]. "This results in a higher cost of cultivation. Moreover, the traditional planting method is time-consuming, causing fatigue and backache due to the longer hours required for careful hand metering of seeds if crowding or bunching is to be avoided. Most farmers are small and marginal landholders in India, hence they cannot afford tractor-drawn planters or any machinery" [6]. Farmers have been using manual devices for swinging operations, they were time-consuming, laborious, boring, tedious, and costly also [7].

So, keeping the above point in mind, the present study was undertaken with a specific objective to test the single-row manual seeder as per IS Code: 6316-1993 and to find out the cost of sowing [8].

2. MATERIALS AND METHODS

A manually operated single-row seeder was used for precision sowing operation. It consisted of a main frame, press wheel, seed hopper, seed drum, seed roller, and tooth.

2.1 Machine Components

A main frame for accommodating all components of the manually operated seeder. The main frame was fabricated using GI pipe of 15 mm outer diameter with 3 mm thickness, as per standard dimensions given in IS code 6316-1993. A seed box consists of reinforced plastic. It is filled with seeds and the hopper capacity is 4 kg. It is directly attached to the seed metering mechanism unit.

This manual seeder can adjust the planting distance and seeding depth to realize the scientific planting of different crops and ultimately maximize the yield. The plant spacing can be adjusted by changing the number of seed mouths.

2.2 Choose the Right Planting Space

According to the above comparison table, determine the model corresponding to the required plant spacing. Model 12-mouth is composed of 12 mouth blocks and 12 × 12 spacers. Therefore, to adjust to Model 10-mouth, you need to subtract 2 mouth blocks and replace the spacers with 10 × 10 spacers and so on.

2.3 Please Follow the Steps Below to Change the Plant Spacing

1. Find the disassembly point on the machine body, remove the screws around the mouth block corresponding to the disassembly point, and take out the mouth block.

2. Take out the mouth blocks and spacers that are not needed, such as changing to a 9-mouth seeder, that is, take out 3 mouth blocks and all the spacers.
3. Install the upper #9 spacers in turn; the order is one mouth block and one #9: spacer.
4. Locate the left mounting point, remove the screws corresponding to the spacer at the left mounting point, and replace the #9 spacer and screw on the screw.
5. Put back the mouth block corresponding to the disassembly point, and screw on the sur- rounding screws.

2.4 Quickly Adjust the Plant Spacing Method

There is a small window on the manual seeder, you can control the opening and closing of the mouth by removing the screw in the small window, and the 12 mouths can be easily converted into 6 mouths (the mouth will not move when you unscrew the screw).

List 1. The following table shows the corresponding table of the number of seed mouths and plant spacing

Number of mouth / Planting space	12	10	9	8	7	6	5	4	3	2
cm	15	17	19	21	23	28	23	42	53	85
inch	4.5	5.5	6	6.5	7	11	12	16.5	21	33

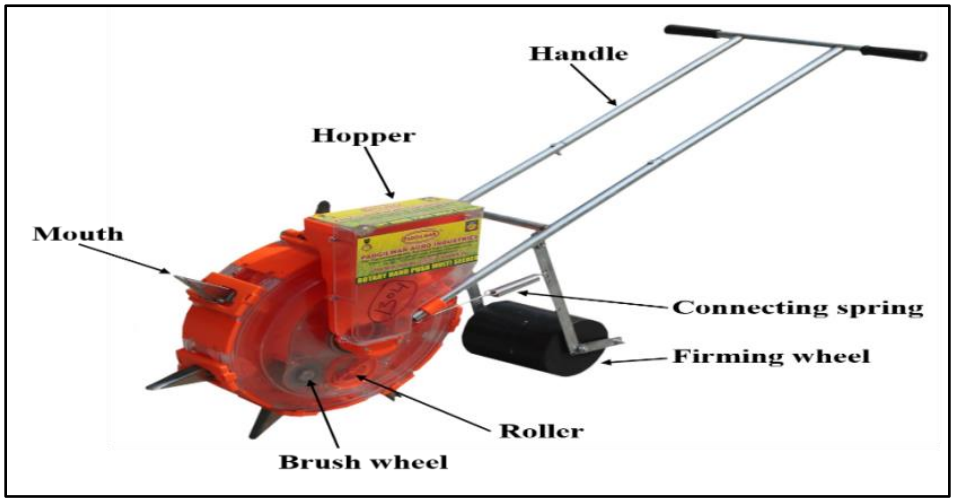

Fig. 1. View of manual seeder

Fig. 2. Adjust the plant spacing

Table 1. Adjustment of the plant spacing

6-mouth spacing	Remove a white screw from every other mouth
4-mouth spacing	Remove two white screws from every other mouth
3-mouth spacing	Remove three white screws from every other mouth
2-mouth spacing	Remove five white screws from every other mouth small window white screw

2.5 Choose the Suitable Seed Roller

Please choose a suitable seed roller according to the size of the seed (usually, the hole on the seeding roller should be larger than the largest seed in the seed). To replace the seed roller, please follow the steps shown in the Fig. 3.

2.6 Attentions

1. Please sift the seeds before sowing to remove small impurities, mildew, and damaged seeds. When using the seed coating agent, it should be dried before use, otherwise it will affect the accuracy of seeding. When you find that the seeding is not smooth, you should first check whether the seeds are clumping. The astringent seeds are mixed with 5% talcum powder or lead powder.
2. Before planting, a trial seeding should be carried out to confirm whether the number of seeds and plant spacing is accurate, and the planting can be formally conducted after the trial is accurate.
3. Please don't use it on rainy days or in flooded lands, and only use it when the soil is dry and wet enough for sowing.
4. Check whether the mouths are reset at any time during sowing. If it is not reset, it must be cleaned up in time. The sowing speed is generally 20-25 meters per minute.
5. When it is found that the amount of seeds used per acre is significantly reduced, please check in time for blockages or other failures to avoid causing losses to you.
6. If the agricultural agent on the seed is not dried and used, or the seeding roller is chosen improperly, the plant will not be responsible for problems such as incomplete emergence. Maintenance of the whole machine does not need to add lubricating oil, just keep it clean. In the process of use, always check all parts and whether the screws are loose, and if they are found, they should be dealt with and repaired in time.
7. To ensure the service life of the machine, please remove the mouth clay and fertilizer in time at the end of each sowing, and thoroughly clean the soil after planting for the next use.

2.7 Performance Evaluation of Manually Operated Manual Seeder

The tests of the manual seeder were conducted under both laboratory and field conditions. The manual seeder was tested in two crops cotton and castor. During its performance evaluation, its

Fig. 3. Change the suitable seed roller

field capacity, efficiency, plant damage, energy consumption, power requirement speed of operation, cost of operation, etc. were determined. The following aspects of its performance were assessed: The metering ability of the metering device. The degree of damage to the seeds. The evenness of spacing of the seeds. The quality of work in terms of the ability of the Seeder to feed, place, and cover each seed satisfactorily. The soundness of construction. Laboratory testing was done by discharging seeds on a grease-coated board placed on the floor. The resulting seed pattern was representative of the performance of the metering device with its seed tube but did not show the effect of bouncing in the furrow. For field observations, the planter was also operated on a previously plowed piece of land [9].

2.7.1 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 capacities 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.
   Damage percentage (%) = weight of damaged seeds weight of total seed collected × 100
3. **Uniformity of Seeding** - To determine whether the drill is placing the speed uniformly or not. It was done by using the sand bed method.

2.7.2 Field test

2.7.2.1 Coefficient of uniformity

The spacing between two consecutive seeds was measured for a length of 30 m run in a row. The average value was found and the coefficient of uniformity was calculated by following the formula,

Coefficient of uniformity (%) = (1− Σ|×− $\overline{X}$|N$\overline{X}$) x 100

2.7.2.2 Depth of seed placement

The manual seeder 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 a depth gauge.

2.7.2.3 Operating speed

The operating speed was calculated for the manual seeder by observing the productive time taken to travel the 30 m length of the plot with the help of a stopwatch.

2.7.2.4 Theoretical field capacity

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

Theoretical field capacity (ha/h) = Width of coverage (m) x Speed (km/h)/10

2.7.2.5 Effective field capacity

The actual area covered with time including the time loss is known as the actual or effective field capacity [10].

Actual or Effective field capacity (ha/h) = Area of plot (ha) Time taken (h)

2.7.2.6 Field efficiency

Now, the field efficiency was calculated as follows:

Field efficiency (%) = Actual field capacity (ha/h) Theoretical field capacity (ha/h) x 100

2.7.2.7 Labour requirements

The number of persons required to operate the manual seeder was considered to calculate the total labor requirement.

2.7.2.8 Draft measurement

“A spring-type dynamometer (0-100 kg) was used to measure the draft required to operate the manual seeder. D = Draft (kg), P = Pull/Push (kg), and θ = angle with horizontal, (degree)” [10].

The draft is measured by using the formula:

$D = P \cos\theta$

Fig. 4. Laboratory testing of manual seeder

Fig. 5. Field testing of manual seeder

2.7.2.9 Energy consumption

The manual seeder was operated manually in the field. The human energy utilized in mechanical sowing operations in the field for manual seeder was evaluated as per described by Chaudhary et al., [11]. It was calculated by the following formula:

$$Em = 1.96\ Nm \times Tm$$

2.7.2.10 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" [10]. "Automated weed management tools in crops are needed to reduce or eliminate hand-weeding because of labour shortages and cost" [12].

3. RESULTS AND DISCUSSION

Single row manual seeder was field as well as laboratory tested as per IS Code: 6316-1993 at the research plot of Testing and Training Centre of Farm Machinery, Junagadh Agricultural University, Junagadh.

3.1 Laboratory Test

3.1.1 Calibration

The manual seeder was calibrated as per the recommended seed rate of cotton and caster crops i.e. 3.0 kg/ha. The calibrated seed rate was found for cotton and caster seed as 2.85 kg/ha and 2.88 kg/ha respectively at 100% hopper capacity.

Regression coefficients were tested based on the t-value. Model equation for the prediction of seed rate (kg/ha) was given for crops like cotton and castor respectively by,

Seed rate (%) = 0.250 (Hopper capacity, %) + 1.875
Seed rate (%) = 0.213 (Hopper capacity, %) + 2.005

3.1.2 Seed damage test

The number of seeds with visible damage in the sample was taken and mechanical damage was

found for cotton and caster seed at 7.84% and 7.74% respectively, at 100% hopper capacity. This was due to the shearing of seed in between the seed drum and the metering wheel. Regression coefficients were tested based on the t-value. Model equation for the prediction of seed rate (kg/ha) was given for crops like cotton and castor respectively by,

Seed damage (%) = 0.849 (Hopper capacity, %) + 4.265
Seed damage (%) = 0.774 (Hopper capacity, %) + 4.54

3.1.3 Seed uniformity test by sand bed method

The average distance between cotton and castor seeds was found about 62 cm and 64 cm respectively, which was near the recommended (60 cm) for both cotton and castor crop recommendation. The placement of seeds was near the row straight line, which is almost to maintain in manual sowing.

3.2 Field Test

3.2.1 Coefficient of uniformity

The coefficient of uniformity for manual seeder for cotton and castor seed was found 91.69% to 93.23% respectively.

3.2.2 Depth of seed placement

The depth of seed placement by manual seeder for cotton and castor was found as 5.7 cm and 5.9 cm respectively in the field and the recommended depth is 4 to 6 cm for both crops.

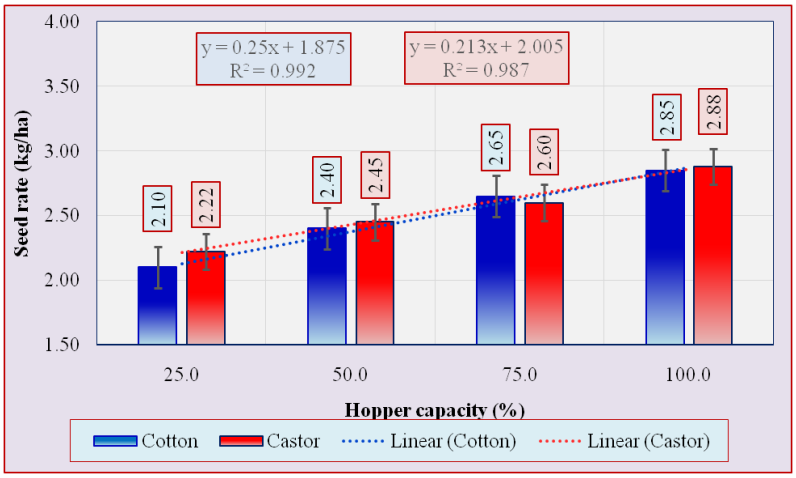

Fig. 6. Graphical representation of seed rate at different hopper capacity

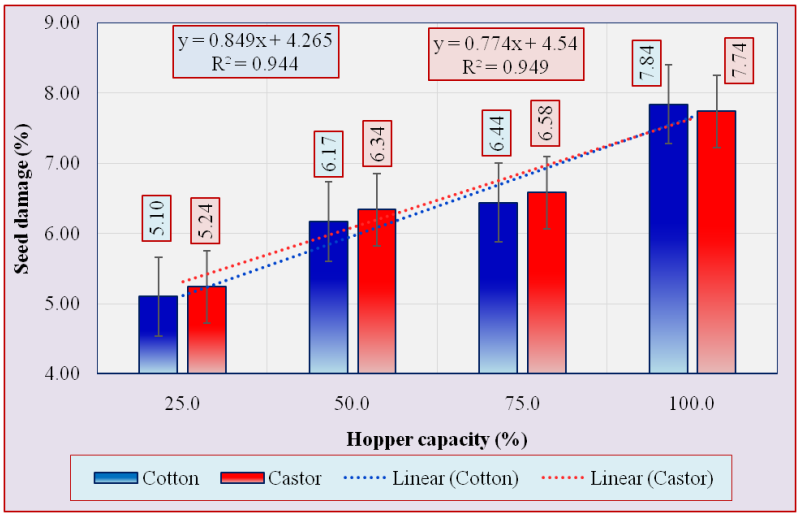

Fig. 7. Graphical representation of seed damage at different hopper capacity

3.2.3 Operating speed

Time was recorded to cover a 30 m distance in each pass and average speed was calculated. The average speed of manual seeder for cotton and castor crops was found as 1.82 km/h and 1.84 km/h respectively.

3.2.4 Theoretical field capacity

"The theoretical field capacity of manual seeder for cotton and castor crops was found as 0.193 ha/h same for both. Average bulk density of whole cotton stalk and shredded cotton stalk was found as 29.90 kg/m3 and 147.02 kg/m3 respectively" [13]. "The performance of weeder was evaluated at three different forward speed of S1, S2 and S3 is 1.0 - 1.5, 1.5 - 2.0 and 2.0 – 2.5 km/h respectively" [14].

3.2.5 Effective field capacity

The effective field capacity of manual seeder for cotton and castor crops was found as 0.166 ha/h to 0.171 ha/h respectively.

3.2.6 Field efficiency

The average field efficiency of manual seeder for cotton and caster crops was found as 86.01% and 88.60% respectively. It is higher than the manual sowing and other manually operated seeder as well as planters.

3.2.7 Draft measurement

The pull of the manual seeder for cotton and castor crops was found as 13.50 kg and 14.80 kg respectively and the average pull angle (θ) was observed at 45 degrees. Therefore based on this, the average draft measured in manual seeder for cotton and caster crops was found as 9.54 kgf and 10.46 kgf respectively. The draft of other seeders was more because of its weight, which is heavier than other planters.

3.2.8 Energy consumption

The energy used by manual seeders was less because only one labor was required. The energy consumption for cotton and castor crops was found as 10.93 MJ/ha and 11.04 MJ/ha respectively.

3.2.9 Cost of operation

"The cost of sowing this manual seeder for cotton and caster crops was 437.25 Rs/ha and 446.82 Rs/ha respectively. The total operating cost of a manual seeder was low because of one labor requirement for sowing operation and also required less seed rate as compared to other seeder-type machines. Different types of thermochemical even biological processes have been adopted to convert biomass into value-added products" [15].

List 2. The following table shows the Test performance result of manual seeder in cotton and castor crops

Sl. No.	Name of test	Cotton	Castor
A	**Laboratory test**		
01	Seed rate (kg/ha)	2.85	2.88
02	Seed damage (%)	7.84	7.74
03	Seed uniformity (cm)	62	64
B	**Field test**		
01	Coefficient of uniformity (%)	91.63	93.23
02	Depth of seed placement (cm)	5.7	5.9
03	Speed of operation (km/h)	1.82	1.84
04	Theoretical field capacity (ha/h)	0.93	0.93
05	Effective field capacity (ha/h)	0.166	0.171
06	Field efficiency (%)	86.01	88.60
07	Draft (kgf)	9.54	10.46
08	Energy consumption (MJ/ha)	10.93	10.04
09	Cost of operation (Rs/ha)	437.25	446.82

4. CONCLUSIONS

From the testing and evaluation of the manual seeder, the following conclusions emerged during the study.

1. The manual seeder has a simple mechanism and can be easily operated by the farmers.
2. Laboratory test of manual seeder as seed rate (2.85 and 2.88 kg/ha) and seed uniformity (62 and 64 cm) for cotton and castor seed respectively.
3. Field test of manual seeder as seed rate (2.85 and 2.88 kg/ha) and seed uniformity (62 and 64 cm) for cotton and castor seed respectively.
4. Field test of manual seeder as the coefficient of uniformity (91.63 % and 93.23 %), depth of seed placement (5.7 cm and 5.9 cm), and speed of operation (1.82 km/h 1.84 km/h) of cotton and castor crop respectively.
5. Field test of manual seeder as theoretical field capacity (0.93 ha/h and 0.93 ha/h), effective field capacity (0.166 ha/h 0.171 ha/h), field efficiency (86.01 % and 88.60 %), draft (9.54 kgf and 10.46 kgf), energy consumption (10.93 MJ/ha and 10.04 MJ/ha) and cost of operation (440 Rs/ha and 445 Rs/ha) of cotton and castor crop respectively.
6. The cost of sowing by this manual seeder was found low as compared to manual sowing.
7. All these tests indicate that the manual seeder was easily pulled by a normal man.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
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