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Development and Performance Evaluation of Garlic Planter

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Authors' contributions

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

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ABSTRACT

The study focuses on the development and performance assessment of a garlic planter, conducted at the Swami Vivekanand College of Agricultural Engineering and Technology & Research Station, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The evaluation considered various parameters, including miss index, multiple index, quality of feed index, field capacity, emergence rate index, percentage emergence, and yield attributing characteristics etc. The findings contribute to enhancing garlic cultivation practices, potentially boosting productivity and efficiency in the field.

Keywords: Missing index; multiple index; quality feed index; emergence; garlic planter.

1. INTRODUCTION

In 2022, India produced 3.27 million metric tons of garlic. Most of this production is consumed locally in India but garlic exports increased by 159% to 57,346 tonnes in 2022-23 [1]. In India, garlic is majorly grown in Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Bihar, Andhra Pradesh, Haryana and Chhattisgarh. Madhya Pradesh is

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the largest garlic producing state in India [2], accounting for around 35% of the total garlic production in the country. The increasing trend of production and productivity of garlic in India, clearly shows the emerging interest of Indian farmers in garlic production. Chhattisgarh is a state located in central India, and its climate and soil are conducive to the cultivation of several crops, including garlic. Garlic farming has the potential to be a profitable enterprise in Chhattisgarh, given the increasing demand for garlic in domestic and international markets. The total area of garlic cultivation in Chhattisgarh in 2020-21 was 1.34 thousand hectares, with the production and productivity of 3.05 thousand tonnes and 2275 kg/ha, respectively [3].

The recommended seed to seed spacing and depth of seed placement varies according to the type of crop and agro-climate conditions to achieve optimum yields [4]. Planting of garlic is propagated through cloves. The cloves are separated from the bulbs and planted with the pointed side up, at a depth of about 3-5 cm. The cloves are generally spaced around 10-15 cm apart in rows and plant to plant is 7.5-10 cm. After placement of the cloves in the furrow they should be covered properly by the soil [5]. Manual method of garlic planting is adopted in the Chhattisgarh is time consuming process.

Now various kinds of garlic planters are developed and available. A manually operated garlic bulb planter with two bicycle wheels and a toothed rubber belt consisting of sponge teeth was designed and fabricated that significantly reducing the human power and cost. United States developed a garlic clove planter allowed garlic to be planted upright with its blunt root part pointing down toward the ground giving effective germination after planting. A roller-type metering system containing a seed hopper, an electric motor-driven vertical roller-type seed plate, and a seed counter also effectively reducing the cost of sowing [6]. The performance of a developed garlic planter evaluated in Uttar Pradesh, India, whose field capacity and field efficiency at forward speed of 1.8 km/h were 0.018 ha/h and 78%, respectively [7]. The manual garlic planter designed had a capacity of 0.336 ha/man-day, an effective field capacity of 0.042 ha/h, and a field efficiency of 81.02% [8]. During the sowing season the scarcity of labour results in delayed sowing this reduces yield [9].

It is well known fact that row planting is very important operation and good crop can be achieved if it is timely carried out with the engagement of labour only the planting operation can be completed timely all time. Hence a mechanical planting on a good seed bed is very much required for successful cultivation of garlic. Therefore, for timely and precision planting of good garlic planter is needed. This research aims to develop a power operated planter capable of simulating and planting garlic cloves at a predetermined depth, row and plant spacing on the field.

2. MATERIALS AND METHODS

The study was conducted in the Swami Vivekanand College of Agricultural Engineering and Technology & Research Station, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The garlic clove planter was developed and evaluated in the field by considering various parameters discussed below.

2.1 Development of Garlic Planter

The major component of the garlic planter were a frame for stability, a seed box for clove storage, a metering mechanism for precise clove dispensing, and a transmission system for power transfer from ground wheels. The cup feed metering mechanism provided a distinct advantage in achieving consistent spacing between cloves, optimizing garlic growth, where furrow openers, seed tube, scraper and covering unit were provided to ensure the suitable placement of seed into the soil. The cup size of the garlic planter was 10% greater than the clove size was selected for the machine, which was found effective in previous research. The garlic planter was developed in the workshop of Department of Farm Machinery and Power Engineering, Swami Vivekanand CAET&RS, IGKV, Raipur, Chhattisgarh. Specification of developed garlic clove planter is depicted in Table 1.

2.2 Performance Evaluation

The developed garlic planter was tested in the field by considering average speed 2.75 km/h with depth of sowing 60 mm that was found best for sowing from various literatures. The following parameters were observed during testing of the developed garlic planter.

Table 1. Specification of developed garlic clove planter

S.No.	Particulars	Values
1.	Over all dimension (L×W×H), mm	2122 × 2250 × 1363
2.	Required Source of power	50-55 hp tractor
3.	Soil condition for which the machine is used	Upland friable soil
4.	No. of rows	12
5.	Furrow opener	Inverted T type
6.	Seed hopper, (Nos.)	1
7.	Operating/working width(mm)	1800
10.	Seed metering mechanism	Cup feed type
11.	Depth control	Depth control wheel
12.	Power transmission	Chain, sprockets and set of spur gear
13.	Weight of machine, kg	420

2.2.1 Miss index (MI)

The miss index was created when cup fails to drop seed within desired spacing. It should be smaller for better performance. Miss index is indicated by MI. The percentage of spacing in miss index is greater than 1.5 times of the theoretical spacing [10].

$$MI = \frac{n_1}{N} \quad (1)$$

Where,

MI = Multiple index, %;
n_1 = Number of spacing, and
N = Total no. of observation.

2.2.2 Multiple index (DI)

The multiple index was created when more than one seed was dropped by a cup within desired spacing. The value of multiple indexes should be smaller for better performance. Multiple index is indicated by DI. The percentage of spacing in multiple index is less than or equal to half of theoretical spacing [11].

$$DI = \frac{n_2}{N} \quad (2)$$

Where,

DI = Multiple index, %;
n_2 = Number of spacing; and
N = Total no of observation.

2.2.3 Quality of feed index (Q)

The quality of feed index (Q) is the measure of how often the spacing was close to the theoretical spacing. It is the percentage of spacing that are more than half but not more than 1.5 times the theoretical spacing. The quality of feed index is mathematically expressed as follows [12]

$$\text{Quality of feed index (Q)} = 100 - (\text{miss index} + \text{multiple index}) \quad (3)$$

2.2.4 Theoretical field capacity (FC_t)

Theoretical field capacity is the rate of field coverage by planter without any interruptions. The theoretical field capacity was calculated by following formula [13].

$$FC_t = \frac{w \times s}{10} \quad (4)$$

Where,

FC_t = Theoretical field capacity, ha/h;
W = width of planter, m; and
S = forward speed of tractor, km/h.

2.2.5 Effective field capacity (FC_a)

It is actual average rate of coverage by the machine in the field. It was calculated by using following formula [13,14].

$$FCa = FE \times FCt \quad (5)$$

Where,

FC_a = Effective field capacity, ha/h; bna
FE = Field efficiency, %; and
FC_t = Theoretical field capacity, ha/h.

2.2.6 Field efficiency (FE)

Field efficiency is the ratio of effective field capacity to theoretical field capacity [15]. The field efficiency of planter was calculated by following formulae.

$$FE = \frac{FC_a}{FC_t} \quad (6)$$

Where,

FE = Field efficiency, %;
FC_a = Effective field capacity, ha/h; and
FC_t = Theoretical field capacity, ha/h.

2.2.7 Cost of operations

Cost economics was performed in order to estimate the cost of various operations. Cost economics is important for effective machinery management and maintain profit in agriculture production [16]. The cost economic was categorized as fixed cost and operating cost [17]. The total cost of the machine was estimated as Rs. 90964.00 based upon the bill of materials, and cost of operation was evaluated using standard methodology (IS 9164: 1979).

2.3 Mean Emergence Time (MET), Emergence Rate Index (ERI) and Percentage of Emergence (PE)

The following equations were used to calculate the mean emergence time (MET), emergence rate indexes (ERI) and percentage of emergence (PE) as suggested by Karayel and Ozmerzi [18].

2.3.1 Mean emergence time (MET)

MET is a reliable indicator of the time needed to germinate, although it does not correlate well with the uniformity of germination. Instead, it focuses on the day that had the most germination occurrences. The population of seed germination is inversely proportional to mean emergence time. Emergence was measured at three different depth of sowing i.e, 30, 60 and 90 mm.

$$(\mathrm{MET}) = \frac{(\mathrm{N1T1} + \mathrm{N2T2} + \cdots \ldots \ldots .\mathrm{N\,nTn})}{(\mathrm{N\,1} + \mathrm{N\,2} + \cdots \ldots \ldots \ldots \mathrm{N\,n})} \qquad (7)$$

2.3.2 Emergence rate index (ERI)

ERI shows the percentage of germination per day. The higher ERI percentage shows shorter emergence duration and higher germination percentage.

$$\mathrm{ERI} = \frac{\mathrm{Ste}}{\mathrm{MET}} \qquad (8)$$

2.3.3 Percentage emergence (PE)

The percentage emergence does not account for germination speed or uniformity

$$\mathrm{PE} = 100\% \times \frac{\mathrm{Ste}}{\mathrm{n}} \qquad (9)$$

Where,

MET = Mean emergence time;
ERI = Emergence rate indexes;
PE = Percentage of emergence;
N1…Nn = Number of seedlings emerging since the time of previous count;
T1…Tn = Number of days after sowing;
Ste = Number of total emerged seedlings per meter; and
n = Number of seeds sown per meter.

2.4 Yield Attributing Characteristic

The yield attributes of the garlic harvested from the test field were measured which are discussed below.

2.4.1 Polar diameter of bulb

The bulb obtained from observation plants were measured from the both polar ends the with the help of digital vernier calipers.

2.4.2 Equatorial diameter of bulb

The bulb obtained from observation plants were measured from the both equatorial ends the with the help of digital vernier calipers.

2.4.3 Weight of bulb

Weight of ten bulbs from randomly selected plants were measured in electronic balance and average weight of bulb was calculated.

2.4.4 Number of cloves per bulbs

Number of cloves present in 10 randomly selected plants bulb were measured in electronic balance and average weight of bulb was calculated.

2.4.5 Total yield

Garlic yield is typically measured in terms of the total weight of garlic bulbs harvested per unit area, often expressed in kilograms per hectare (kg/ha). This measurement helps assess the productivity of the garlic in the field.

3. RESULTS AND DISCUSSION

The evaluation of the developed garlic planter involves key parameters: the missing index at 5.89% and the multiple index at 6.05%, indicating precision (Table 2). The quality feed index at 88.06% reflects accurate planting. Additionally, the field capacity at 0.42 hectares per hour determines coverage, with field efficiency at 84.38% indicating operational effectiveness. The cost of operation of developed garlic planter was found to be Rs. 2091.65 per hectare.

The emergence of garlic cloves in the field was observed for three different sowing depths, viz. 30, 60, and 90 mm of garlic cloves, and the mean emergence time (MET) was observed to be 10.25, 10.39 and 11.47 days, respectively. The maximum percentage emerge was estimated to be 89.50% at a sowing depth of 60 mm. The emergence rate index (ERI) was 1.15, 1.16 and 1.33 seedlings per day per meter at sowing depths of 30, 60, and 90 mm, respectively, with percentage emergence (PE) of 89, 89.50 and 86%, respectively (Table 3). The emergence percent, days after sowing is shown in Fig. 1, in which it was clear that at 30 mm depth of sowing more emergence found in early days but at 25 days after sowing emergence percent was almost same for 30 mm and 60 mm depth of sowing, where the emerge percent was observed lower at 90 mm depth of sowing for during emergence period.

Table 2. Evaluation of the developed garlic planter

S.No.	Parameter	Values
1.	Missing index, %	5.89
2.	Multiple index, %	6.05
3.	Quality feed index, %	88.06
4.	Field capacity, ha/h	0.42
5.	Field efficiency, %	84.38
6.	Cost of operation, Rs/ha	2091.65

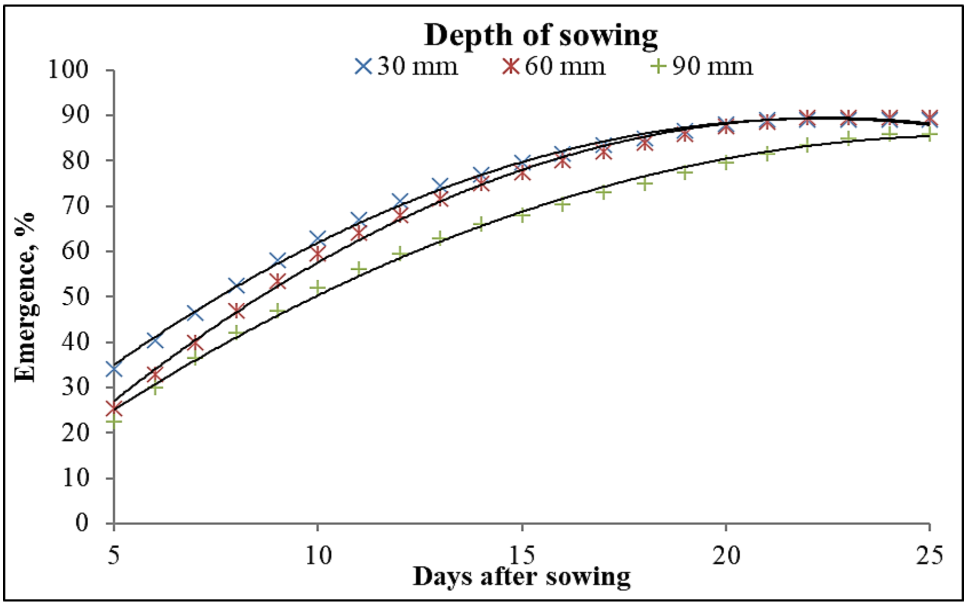

Fig. 1. Emergence of garlic at different depth of sowing

Table 3. MET, ERI and PE of garlic clove after planting with developed garlic clove planter

Depth of sowing	Mean emergence time, days	Emergence rate index, seedling/day	Percentage emergence, %
30 mm	10.25	1.15	89.00
60 mm	10.39	1.16	89.50
90 mm	11.47	1.33	86.00

Table 4. Yield attributes of garlic sown by developed garlic planter

S.No.	Parameters	Values
1.	Plant height	
	70 DAS, cm	41.52
	85 DAS, cm	46.74
	105 DAS, cm	55.63
2.	Polar diameter, mm	34.59
3.	Equatorial diameter, mm	40.19
4.	Weight of bulb, g	19.37
5.	No. of clove	25.96
6.	Weight of 10 clove, g	14.30
7.	Yield, t/ha	3.44

Yield attributes of garlic harvested from the study field is depicted in Table 4. The plant height at 70 days after sowing (DAS) measured 41.52 cm, increasing to 46.74 cm at 85 DAS, and further to 55.63 cm at 105 DAS. The polar diameter of the bulbs was recorded at 34.59 mm, while the equatorial diameter measured 40.19 mm. The weight of the bulb averaged 19.37 grams, with an average of 25.96 cloves per bulb. Additionally, the weight of 10 cloves was measured at 14.30 grams. Ultimately, the yield was determined to be 3.44 tons per hectare, indicating a favorable output from the garlic cultivation process.

4. CONCLUSION

In conclusion, the development and performance evaluation of the garlic planter represent a significant step forward in agricultural machinery technology, particularly in the realm of garlic planting. The meticulous design and testing process ensured the planter's effectiveness in achieving precise and uniform placement of garlic cloves, leading to enhanced seedling emergence and crop establishment. The missing index was observed to be 5.89%, multiple index observed to be 6.05% illustrate accuracy in planting, while the quality feed index at 88.06% reflects quality of planting. Additionally, the maximum percentage emergence was observed at 89.50% with a sowing depth of 60 mm. These findings offer a pathway to improving productivity and efficiency in garlic cultivation, thereby benefiting agricultural practices and contributing to food security.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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