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Research Article

Garlic (*Allium sativum* L.) Clove Planter: The Mechanization in Garlic Cultivation

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ABSTRACT

In this study the traditional method of garlic planting is brought under the roof of farm mechanization by developing the tractor operated garlic clove planter. Garlic is commonly known as *Allium sativum* L. and it belongs to "Alliaceae" family. From ancient times garlic had been planted by manually. Even though garlic crop is more profitable but due to laborious planting operation the area under the garlic cultivation is reducing. In view of the above considerations under this study development of nine row garlic planter using spoon type precision metering mechanism for garlic planting. Actual field capacity was found to be 0.32 ha/h, which is 168 times of the manual dibbling and 21 times of the manual garlic planter. The payback period of the developed planter was calculated 2.27 years. The developed planter tested in laboratory and field. The quality of feed index, mechanical seed damage, effective field capacity and field efficiency were found to be 86.82%, 5.51%, 0.32 ha/h and 80.33%, respectively.

Keywords: Garlic clove planter; Spoon type metering mechanism; Quality of field index; Mechanical seed damage; Field efficiency

INTRODUCTION

Garlic is commonly known as *Allium sativum* L. and it belongs to "Alliaceae" family. It is a frost tolerant, semi perishable vegetable cash crop use as the spices, condiments and medicinal purpose. The sticky juice within the bulb and cloves is used as an adhesive in mending glass and porcelain. It also possesses nematicidal and insecticidal properties hence can be used for control of cabbage root fly and red mite in poultry. Garlic along with cinnamon is used as a fish and meat preservative, It displays antimicrobial property at temperatures as high as 120°C, the combination can also be used to preserve fried and deep fried foods. It requires cool and moist climate during growth period and warm dry weather during maturity and it gives high yield in well drained fertile loamy soil having soil pH between 6 to 7. Clay soil and sandy soil having alkaline and saline nature doesn't use for sowing garlic due to compact particle arrangement in the soil resist the growth of bulb.

Garlic is also an important foreign exchange earner for India with a total export amounting to 15440.59 MT (7285.00 lakhs) [1]. Garlic is grown worldwide in 1.4 million hectares, with a total production and productivity of 24.54 million tons and an average productivity of 16.26 t/ha. India, although ranks second in area and production, the productivity is very low (5.76 t/ha). Among the all states of India, Madhya Pradesh having the highest area of cultivation (81,170 ha), with a production of 4,24,500 tones. Though, the productivity of garlic in Punjab was found to be highest (11.41 t/ha) [2].

The advanced technologies of farm mechanization with improvement in the existing design, newer material and production techniques will cater to the needs of farms [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].

Garg and Dixit developed and evaluated the performance of a single row manually operated planter for garlic planting [5]. The machine was consisting of vertical discs with spoons type seed metering mechanism. The field capacity of the machine varied from 0.03 to 0.04 ha/h. A tractor-operated garlic planter was developed under the AICRP Farm Implements and Machinery, CTAE, Udaipur [6]. The field capacity, field efficiency, and cost of planting were 0.51 ha/h, 77% and ₹1,000 per hectare, respectively. Nare et al. (2014) designed and developed a self-propelled garlic clove planter [7]. The spoon type metering mechanism was used for metering the

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garlic clove. The miss index, multiple index, seed damage, actual field capacity and field efficiency of self-propelled garlic planter was 2.67%, 8.0%, 1.46%, 0.065 ha/h and 79.84%, respectively.

The farmers are generally sowing garlic by manual method, which is highly labour intensive and time consuming. To overcome such circumstances and enhance productivity of garlic on Indian farms, the tractor operated garlic (*Allium sativum* L.) clove planter was developed.

MATERIALS AND METHODS

In this study, an innovatively developed tractor operated, ground-wheel driven, nine row garlic precision planters capable of planting nine rows of garlic cloves at a spacing of 10×15 cm was developed and tested in department of Farm Machinery and Power Engineering, JAU, Junagadh, Gujarat. The GG4 garlic variety mostly cultivated in Gujarat was used for the study. The spoon type metering mechanism was designed and developed considering the physical properties of garlic. The metering mechanism was developed in such way that 10 elliptical spoons were fitted on the periphery of a metering roller of diameter 235 mm. The final operational parameters of the metering mechanism were decided based on average seed spacing, miss index, multiple index, quality of feed index, seed rate, and mechanical seed damage. There were three sizes of metering spoons (10%, 20% and 30% more than max. clove dimension) and three forward speed (2.5, 3.0 and 3.5 Km/h) was used for the laboratory evaluation of metering mechanism and on the basis of results obtained in laboratory, the spoon size 10% more than maximum clove dimension use for final prototype and 2.5 km/h forward speed use for the performance evaluation of prototype. Figure 1 shows the detailed view of the developed garlic (*Allium sativum* L.) clove planter. Metering mechanism consists of metering roller, metering spoon and shaft and chain and sprocket mechanism is use for power transmission.

Metering roller

It was made of mild steel having 235 mm and 3 mm thickness with the boss at one side. The outer diameter and thickness of the boss were 26 mm and 4 mm respectively. The holes of 6 mm diameter were made on the hub to fix roller on the shaft. For fixing the spoon on metering roller 10 holes of 6 mm diameter at 110 mm radius were made on the rollers. The numbers of spoons (n) were determined by the following relationships (eq. 1).

$$n = \frac{\pi \times D \times (1 - \alpha)}{N_r \times s \times f} \quad (1)$$

Where,

D=Diameter of the transmission wheel, cm; α=Skid, fraction

N_r=Speed ratio, transmission wheel to roller; S=Spacing required between two seeds, cm

Verma suggested diameter of the ground wheel is 22.52-40 cm for bullock drawn planter and 40-60 cm for tractor drawn planter [8]. In order to adjust the number of cups and plant spacing, the diameter of the ground wheel was taken 460 mm in present case (eq. 2).

$$n = \frac{\pi \times 460 \times (1 - 0.1)}{1.5 \times 100} = 10 \quad (2)$$

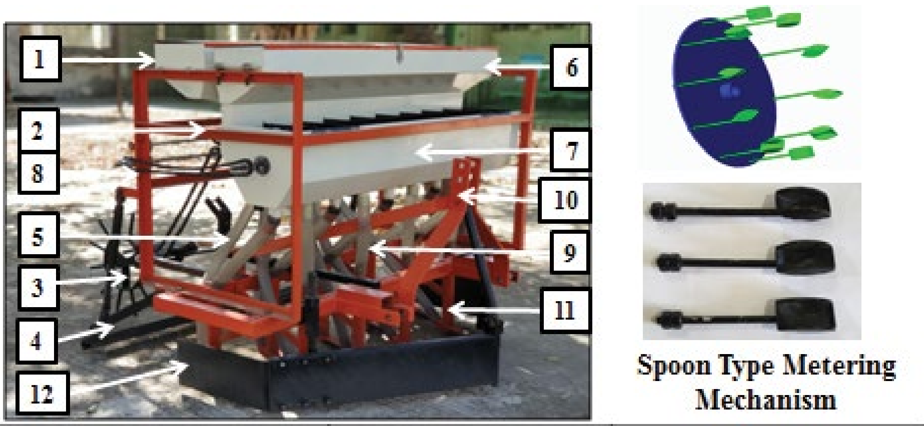
Considering the availability of the gears the speed ratio N_r was kept 1.5:1. The amount of skid of transmission wheel was assumed to be 10% and required spacing of 10 cm in combination with D, N_r and α is substituted in the above equation 3.16. The numbers of spoon were calculated as 10.

Metering spoons

The size of metering spoon was decided after evaluating the physical properties of garlic clove [9]. Three different sizes of spoons were prepared by using MS sheet. The shape of the spoon is elliptical with 180o to the rod of three sizes viz. (S1) 10% more than the maximum seed dimension, (S2) 20% more than the maximum seed dimension and (S3) 30% more than the maximum seed dimension.

Performance parameters

Average seed spacing: Average seed spacing (S) indicates the average value of spacing measured between two consecutive seeds in a row. It was measured using a standard measuring scale (eq. 3).



1. Fertilizer hopper	5. Fertilizer tube	9. Seed tube
2. Fertilizer metering box	6. Seed hopper	10. Three point linkage
3. Ground wheel	7. Seed metering box	11. Furrow opener
4. Covering Device	8. Frame	12. Bed former

Figure 1: Detailed view of the developed garlic (*Allium sativum* L.) clove planter.

$$S = \frac{\sum S_a}{N} \quad (3)$$

Where,

S_a=Actual spacing between two consecutive seeds; N=Total number of observations

Miss index: Skips or misses are created when spoon fails to pick up and deliver seeds to the drop tubes. The missing percentage is presented by an index called Miss Index (MI) which is the percentage of spacing greater than 1.5 times the theoretical spacing [10]. Smaller values of MI indicate better performance (eq. 4).

$$MI = \frac{n_1}{N} \quad (4)$$

Where,

n_1=Number of spacing in the region ≥ 1.5 times of theoretical spacing,

N=Total no. of observations

Multiple index: Multiples are created when more than one seed is delivered by a spoon. The multiples percentage is represented by an index called Multiple Index (DI) which is the percentage of spacing that is less than or equal to half of the theoretical spacing [11]. Smaller values of DI indicate better performance (eq. 5).

$$DI = \frac{n_2}{N} \quad (5)$$

Where,

n_2=Number of spacings in the region ≤ 0.5 times of theoretical spacing,

N=Total no. of observations.

Quality of feed index: To achieve the desired seed rate in the precision planter, the number of seeds per hill recommended shall be one. Hence from the measured values of missing and multiple index, the Quality feed index was calculated by using the following expression [11] (eq. 6).

$$QFI = \frac{n_3}{N} \quad (6)$$

Where,

n_a=Number of spacing in between 0.5 times of theoretical spacing and 1.5 times of the theoretical spacing,

N=Total no. of observations

Seed rate: The seed rate of the metering unit was calculated by using the following formula. It indicates the actual sowing capacity of the metering mechanism (eq. 7).

$$SR = \frac{N_C \times W}{l \times b} \times 10 \quad (7)$$

Where,

SR=Seed rate, kg/ha

N_C=Number of seeds collected during the length of run

W=Thousand seed weight, kg;

l=Length of a run, m

b=Nominal row to row spacing of the crop, m

Mechanical seed damage test: One kilogram of seed sample was randomly selected and 500 g from selected seed sample was filled in hopper and the ground wheel was rotated up to 15 revolutions. Seeds metered by seed metering spoon were collected from seed tube and checked for any visible mechanical damage of seeds including skin removal or crushing [10,12,13]. The damaged seed percentage was calculated from collected seeds and the procedure was repeated thrice (eq. 8).

$$SD = \frac{W_{ds}}{W_c} \quad (8)$$

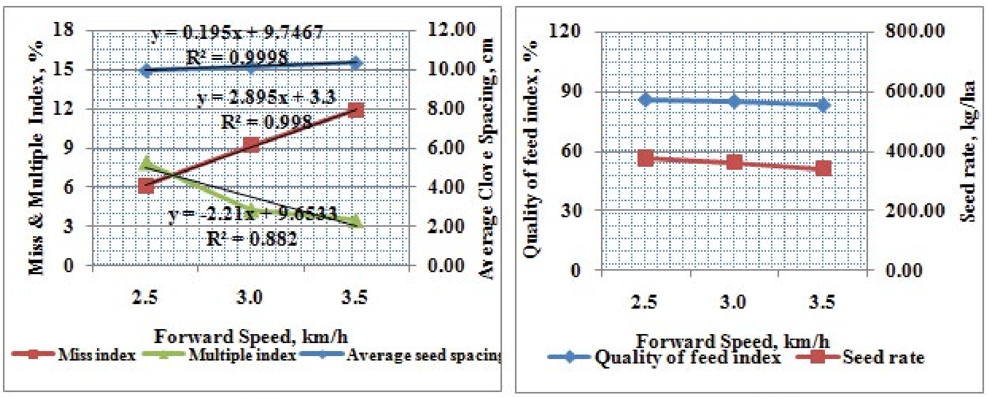
Where,

W_{ds}=Weight of seeds damaged, g; W_c=Weight of seeds collected, g

RESULTS AND DISCUSSION

The variation of seed distribution among the furrow openers was found negligible. Figure 2a shows that that forward speed shows significant effect on average clove spacing, miss index and multiple index. As forward speed increases average clove spacing and miss index increases, but multiple index decreases because of the less time available for pick up the clove by spoon, increase in the skid, more vibration and time available for the clove to set inside the spoon after reorientation of seeds at the bottom of the hopper is reduced to some extent.

Figure 2b shows that as the forward speed of the planter increases resulted into decrease in quality of feed index and seed rate, it was found that the combination of miss and multiple index is shown better result at forward speed 2.5 km/h so that quality of feed



(a) (b)

Figure 2: Effect of forward speed on average clove spacing, miss and multiple index, quality of feed index and seed rate of garlic clove planting.

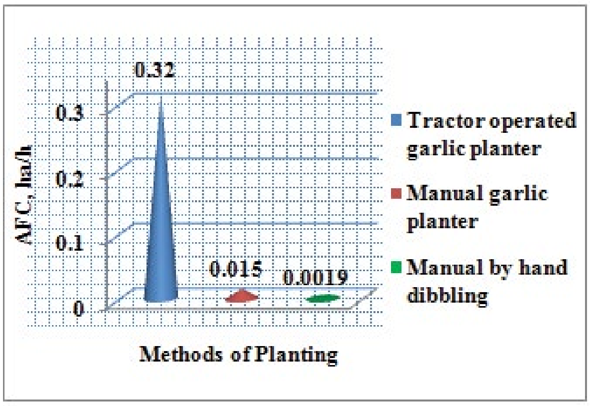


Figure 3: Actual field capacity for planting by different garlic planters.

index is high at this speed. The average seed spacing, miss index, multiple index, quality of feed index and seed rate for GG-4 garlic cloves found were 9.94 cm, 6.12%, 7.91%, 86.82% and 377 kg/ha respectively. The visible mechanical damage in the garlic clove was found to be 5.51%. The effective field capacity and field efficiency of garlic clove planter was found to be 0.32 ha/h and 80.33% respectively. Finally, the results obtained in laboratory experiment were compared with the results obtained in field experiment and it was found similar (Figure 3).

The manual dibbling of the garlic cloves is time consuming operation and requires more labour so that actual field capacity is very less i.e. 0.0019 ha/h, by manual planter 0.015 ha/h. The unavailability of the abundant labour during planting operation mismatch the timely planting resulted reduced in the yield of garlic. To overcome on such problem developed tractor operated garlic planter is the better solutions having actual field capacity 0.32 ha/h, it is 168 times of the manual dibbling and 21 times of the manual garlic planter.

CONCLUSION

The total cost of planting with the developed planter was found to be ₹ 553.63 per hour and ₹ 1677.67 per hectare, which was 2 to 3 times less as compared to manually operated garlic planter ₹ 3604.00 per hectare and manual by hand dibbling ₹ 5200.00 per hectare respectively. The payback period of the developed planter was calculated 2.27 years. It was concluded that the developed spoon type metering mechanism for garlic planting shows the better result with less miss and multiple index with high quality of feed index. The developed machine was minimizing the cost of cultivation due to bed formation, planting and fertilizer application simultaneously with a single machine and reduces human drudgery.

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