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Dayanand Kumbar
Ph.D. Scholar, Department of Farm Machinery and Power Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India

Ajay Kumar Sharma
Vice Chancellor, MBM University, Udaipur, Rajasthan, India

GS Tiwari
Professor, Department of Farm Machinery and Power Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India

AK Mehta
Professor, Department of Farm Machinery and Power Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India

MS Khidiya
Associate Professor, Department of Mechanical Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India

Corresponding Author:
Dayanand Kumbar
Ph.D. Scholar, Department of Farm Machinery and Power Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India

Review paper: Mechanization of garlic planting in India

Dayanand Kumbar, Ajay Kumar Sharma, GS Tiwari, AK Mehta and MS Khidiya

Abstract
Mechanization of agriculture plays a key role in labour and time saving with less drudgery to the workers. Garlic is the one of the most important spice crop in India. Garlic planting by manual is requires huge labour and it is done in bending position which causes lot of discomfort in labour, sometimes it may cause backbone problem in labour. During the peak season shortage of agricultural labour hinder the planting operation. Attempts to mechanize planting operation in garlic have led to the development of farm machinery prototypes in different parts of India. This paper aims to present an overview of the present status and avenues of further mechanizing the planting of garlic in India.

Keywords: Mechanization, agriculture, garlic planter, labour and drudgery

Introduction
India is the second largest producer of garlic in the world after China. It is grown and used as a spice or condiment throughout India. The area, production and productivity of garlic in India are 358 thousand ha, 2920.30 thousand MT and 8.16 t/ha, respectively. The major garlic producing states in India are Madhya Pradesh (63.33%), Rajasthan (14.22%), UP (7.78%) and Gujarat (3.23%) in the year 2019–20 (Anon, 2020) [2]. The average productivity of garlic for different states varies widely and in major garlic producing states, it varies from 5.39 to 10.16 tons/ha in the year 2019-20 (Anon, 2020) [2]. The average global garlic productivity of nearly 16.71 tons/ha in 2011 (Anon, 2013). The area, production and productivity of garlic in Rajasthan are 77.03 thousand ha, 415.48 thousand MT and 5.39 t/ha, respectively in 2019–20(Anon, 2020) [2]. Out of the 12 districts in the state of Rajasthan, Kota zone, including Baran district is the leading zone which has highest area under cultivation. Baran, Chittorgarh and Bundi are the major garlic producing clusters in the state of Rajasthan. The most common variety of garlic is "Yamuna Safed" which again has different variants. The other variety of garlic cultivated in the State is "Bhima Omkar". There are avenues of mechanized cultivation available with present agronomic practices and few would need changes in the current agronomic practices to facilitate mechanization in order to realize the goals of maximum productivity of garlic in India.
Garlic is cultivated by planting single clove vertically with the shoot in the upright position at 50 mm below the soil surface with plant to plant spacing of 100 mm and rows to row spacing of 150 mm. However, farmers have adopted different spacing such as 100 × 100 mm, 75 × 125 mm, 75 × 150 mm and seed rate of 400 to 500 kg/ha to ensure higher germination rate (Kumar *et al*., 2020) [10].

Planting Methods
Garlic is cultivated by planting single clove vertically with the shoot in the upright position at 20 mm below the soil surface with plant to plant spacing of 100 mm and rows to row spacing of 150 mm**.** However, farmers have adopted different spacing such as 100 × 100 mm, 75 × 125 mm, 75 × 150 mm. Big cloves (>1.5 g) are selected for planting at the seed rate of 400 to 500 kg/ha to ensure higher germination rate. Manual planting is very cumbersome and labour intensive operation. It requires about 520 man-h/ha. Several prototypes of seed drills/planters for garlic have been developed in India and have been discussed below.

Manual planter
A single-row manually-operated planter was developed at the Department of Farm Power and

Machinery, Punjab Agricultural University, Ludhiana by Garg and Dixit (2003) [5] was evaluated for sowing garlic (*Allium sativum*). The Machine consists of a planting mechanism and hopper mounted over a wheel hand hoe. The planting mechanism consists of a vertical disc with spoons on its face. The weight of the machine is about 12.0 kg. The machine is operated by 2 persons and another person is required for supplying the seed. The capacity of the machine varies from 0.03-0.04 ha/h. The machine is quite simple in design and costs ₹1200. It is highly labour-saving equipment as it requires only about 83 man-h/ha in comparison to about 520 man-h/ha. The cost of planting using this machine is only 15 percent of the cost of planting by traditional method.

The field performance of manually operated garlic planter was conducted by Gajakos *et al*., (2015) [4]. The weight of unit without cloves is 12 kg. Two persons are required for operating the planter. One person require for pulling the implement in forward direction and another for direction control. The laboratory and field test was conducted for the evaluation of the planter. The field testing was done for calculating the field performance in terms of field efficiency and missing hills percentages. This planter was also tested for cost of operation, and depth of placement of cloves, missed hill percentage and ground wheel slippage. Result shows that the field efficiency was 84.79 per cent. The cost of operation was found to be ₹1214/ha, depth of placement of cloves was 4-5 cm. Time required and cost of sowing by planter was effectively less than manual sowing. Yield and returns of planter were found to be more than manual sowing.

A push-type manually operated garlic planter was designed and developed by Kushwaha *et al.* (2020) [11]. The developed planter was evaluated in the field conditions. The performance parameters like depth of planting, hill to hill spacing, number of seeds per hill, soil cover over the seed, missing hills, operating distance, operating time, operating speed, field capacity and seed rate were checked. The result of testing of the hill to hill spacing, depth of seed placement, number of seeds per hill, soil cover over the seed, missing hills, operating speed and field capacity were found 7.36 cm, 4.98 cm, 1.1, 4.98, 13.46%, 3.31 km/h, and 0.0367 ha/h respectively.

Animal drawn planter

The animal drawn planter still holds relevance in several garlic growing areas having draught animals as the source of power for agricultural operations. ICAR-Central Institute of Agricultural Engineering (CIAE), Bhopal developed a three-row animal-drawn garlic planter consisting of cup type metering mechanism and fertilizer drilling attachment for simultaneous planting and fertilizer placement in the single pass at a depth of 25–40 mm (Kumar *et al.,* 2014). The average draught requirement, field capacity, saving in time, seed spacing, miss index, multiple index, seed damages and labour requirement were reported to be 450 N, 0.06 to 0.08 ha/h, 90%, 108.7±40.1 mm, 10.23, 7.45, 4% and 13 man-h/ha, respectively. The height of hopper can be adjusted with the help of lifting rod handle to regulate the number of cloves in the metering section.

The animal drawn equipment for garlic sowing was developed by Kumar *et al.* (2019) [9] In this study, three types of metering mechanisms (i) commercially available cell type metering mechanism (ii) commercially available spoon type metering mechanism and (iii) cup type metering mechanism were evaluated for sowing garlic cloves. All metering mechanisms were tested under laboratory as well as field conditions. The cup type metering mechanism performed better in comparison to others. Different parameters such as seed spacing, miss index, multiple index, quality of feed index and precision index for cup type metering mechanism were found to be 102 mm, 8.73%, 6.48%, 84.8% and 21.78%, respectively under laboratory conditions and 108.70 mm, 10.23%, 7.45%, 82.32%, and 22.04%, respectively under field conditions. Seed damage varied ranged 2–4%. The planter field capacity and labour requirement were found 0.07 ha/h and 13 man-h/ha, respectively. Total operational cost of sowing using the planter was ₹1042 per hectare. The garlic planter saved more than 90% time as compared to manual operation and the farmer can avail this time in managing other activities.

Self-propelled garlic planter

A self-propelled garlic planter was developed at IARI, New Delhi by Barik (2014) [3] observed field capacity of the planter was 0.09 ha/h at forward speed of 1.5 km/h. The planter has field efficiency of about 78%. It planted the garlic at average planting depth of 2.6 cm. The estimated cost of the machine is ₹50550 with an hourly cost of operation of ₹213. The cost of operation per hectare is ₹2370 as compared to manual hand planting with cost of ₹22500 per hectare. This in turn saves 87.1% per hectare. The breakeven point was found to be 79 h per year, and it was having a payback period of 3 years.

A self-propelled precision garlic planter was designed and fabricated by Nare *et al*. (2014) evaluated in laboratory and field condition for capable of planting three rows of garlic cloves at a spacing of 10 x 15 cm. The theoretical seeding rate and seeding mass rate was calculated to 6, 66, 667 cloves/ha and 0.573 t/ha by taking crop geometry of 10 x 15 cm. The overall length x width x height of the machine is 1,937 x 620 x 922 mm. Twelve elliptical spoons having 180^0 fitted in round plate of diameter 200 mm were used for metering of cloves. A 3 hp diesel engine was used as prime mover of the garlic planter. The theoretical field capacity was calculated as 0.081 ha/h, at a speed of 1.8 km/h, whereas, the actual field capacity was found to be 0.065 ha/h with field efficiency of 79.84%. It was observed that the placement of garlic clove were at uniform depth under a range 4.2 cm to 5.2 cm with a minimum SD and CV of 0.33 cm and 6.92%, respectively. The miss index, multiple index and seed damage were found to be only 2.67, 8.0 and 1.46% respectively, which was within acceptable limit. Operating cost per hour of the machine was calculated as ₹151. For sowing one ha of land the planter required ₹321.50 per hectare which was much more less as compared to manual dibbling method which required 65 man days and required additional cost of ₹2,878.00. Thus, the newly developed machine saves 55.35% of money over traditional methods.

IARI, New Delhi designed self-propelled garlic planter (IARI Annual Report, 2015) having a 2.65 kW petrol engine as a prime mover. In this machine inclined plate metering mechanism was used. Average seed spacing, miss index, multiple index, quality of feed index, precision and seed damage were reported 94.2 mm, 6.8%, 12.72%, 80.48%, 22.67% and 8.26%, respectively. Field capacity of the planter was found to be 0.09 ha/h with a field efficiency of 77.7% while operated at a speed of 1.5 km/h. The average depth of placement was 26 mm.

Tractor operated automatic garlic seed/planter

Tractor operated garlic seed drill/planters were also made by different manufacturers across India. These garlic seeders/planters generally use plastic/PVC roller with groves type metering mechanism. These types of metering mechanism do not maintain clove to clove spacing. Therefore, some research undergone on tractor operated garlic planter in various agriculture universities which are given below.

A tractor-operated garlic planter was developed under the AICRP Farm Implements and Machinery, at College of Technology and Engineering, Udaipur (Anon., 2013). It was provided with plastic roller with six blades like an open impeller of centrifugal pump type seed and fertilizer metering mechanism. The two-row paired hopper and adjustable seed rate are the main features of the 15-row unit which has a minimum row spacing of 150 mm. The observed seed rate during testing was recorded as 550 – 600 kg/ha with a local variety of garlic and 850 – 900 kg/ha of garlic with special variety from Coimbatore. The field capacity, field efficiency, and cost of planting were 0.51 ha/h, 77% and ₹1,000 per hectare, respectively.

ICAR-Indian Agricultural Research Institute (IARI), New Delhi developed 9-rows garlic planter with the vertical cup type metering system (IARI Annual Report, 2014). The row to row spacing, plant to plant spacing, feed index, miss index and multiple index were reported 150 mm, 75 mm, 88%, 2% and 10%,respectively. No visible clove damage was recorded in the laboratory testing. The actual field capacity and field efficiency of the planter was ha/h and 74%, respectively, at the working speed of 2 km/h.

Punjab Agricultural University (PAU), Ludhiana developed 6 row tractor operated garlic planter having spoon size of 23 mm in diameter and 2.5 mm in depth of operation and row to row spacing of 150 mm (Mehta, 2015) [12]. This machine was evaluated for showing of Punjab garlic1 variety on 1 m wide beds and the field capacity of machine was reported 0.18–0.21 ha/h at the speed of 2–2.5 km/h. The average percentage of missing and multiples were 9.13 and 26.70%, respectively.

Zilpilwar *et al*. (2020) [14] developed a tractor operated nine row garlic planter using spoon type precision metering mechanism for garlic planting at Junagad Agriculture University. 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.

Conclusion

In India, most of the garlic cultivation is done by manual labour which is labour intensive and leads to high cost of cultivation. Some research were undergone in various Agriculture Universities on manual planters, self-propelled planters and tractor operated planters. Commercially available tractor operated garlic planters mostly have vertical rollers metering mechanism, in which seed to seed spacing is not maintained. In Indian about 60% of the farmers are marginal and small farmers and they can't afford to purchase tractor operated planters due to high cost. Further research on garlic planting with respect to low cost planting has to undergo to reduce the cost of cultivation which would encourage the farmers to grow in more area and also increases the productivity of garlic.

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