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Animal Drawn Garlic (*Allium sativum*) Planter suitable for Animal Based Farming System

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ABSTRACT

Manual sowing of garlic which is the traditional practice requires 200 man-h/ha, resulting in dense stand of crop necessitating thinning operation. 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 Rs1042 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.

1. Introduction

Garlic (Allium sativum) is one of the most important spice commodities, used for flavoring the dishes and also considered as valuable medicinal item. India ranks second in area (0.165 million ha) and production (1.25 million tons) of garlic, next to China (1.99 million tons). Besides meeting domestic requirements, India exports 2947 MT of garlic worth Rs 4894 lakh (Anonymous, 2013). Productivity of garlic in India is low (5.69 t.ha-1) as compared to countries like Egypt, USA and China. While in India, Madhya Pradesh State is the largest producer of garlic (424500 Mt), but the productivity (5.23t.ha-1) is lower than the all India average (Anonymous, 2016). Traditionally, garlic is sown on small scale with the help of khurpa and commercially sown by Kera method *i.e.* seeds is dropped in furrows by hand. Sowing of garlic by khurpa involves very high labour requirement of about 56–62 man days.ha-1 (Garg *et al.,* 1998).

During the last decade there has been a rapid growth of power operated machinery. Many metering mechanism have been developed for the sowing of garlic clove. Garg and Dixit (1998) developed a single-row manually operated garlic planter. The machine consisted of a planting mechanism and a hopper mounted over a vertical disc with spoons on its face. Field capacity of the planter ranged between 0.03–0.04 ha.h-1. It was highly labour saving equipment as it required only about 83 man-h.ha-1 in comparison to 200 man-h.ha-1 with traditional practice. Yenpayub *et al.,* 2002 studied three types of metering mechanism of garlic which included; i) inclined metering plate ii) vertical metering plate and iii) spring plate. Two models namely vertical metering plate with triangular grooves and bucket type garlic planter were studied. The bucket type garlic planter resulted in uniform metering of garlic cloves.

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The percentage of broken was very low (0.23%). The 8-row garlic planter was tested under actual field conditions and width of garlic planter was 8000 mm. Speed of operation was 2.63 km.h^{-1} and ground wheel skid was 23%. The average depth and width of planting were 26mm and 47mm, respectively. Field capacity was 0.31 ha.h^{-1}. Based on this study, it was concluded that bucket-type metering mechanism was satisfactory. Bakhtiari and Loghavi 2009 developed tractor drawn three row precision planter to sow the garlic clove on raise bed. The planter was design to pick single garlic clove and drop directly on the bed from hopper. The planter unit made of furrower, bed shaper, seed hopper, seed tubes, furrow openers *etc.* the miss index and multiple index were reported 12.30 and 2.43, respectively. The seed rate was found up to 222,000 per hectare which was found less than general recommendation. The seed spacing and depth were found 12.3 and 2270 mm and 1230 mm, respectively.

Benjaphragairat *et al.,* 2010 developed 10 rows garlic planter comprised of bucket type metering system and shoe type furrow openers with row to row spacing 250 mm. The performance evaluation of the planter was evaluated in farmers field which resulted average seed to seed distance117 mm and field capacity 0.13 ha/h. The minimum variation of seed to seed distance was found at combination of operational speed 1.68 km/h and lowest seed delivery tube height equal to 300 mm from the ground surface. The germination percentage of seed was 74.57% and skid of the planter 10.36% was found. Many of the animal operated technologies have become obsolete resulting in drastic decline in use draft animal. On the other hand, rising cost of diesel and electricity have resulted in significant increase in the cost of operation of power operated machinery. Small and marginal farmers which contribute 85% of land holding (Anonymous, 2015) still depend upon animal operated machinery for most of the operations other than primary tillage. It is estimated that at present 50% of net sown area is sown by draught animals (Chaudhuri and Singh, 2013). Moreover, because of lack of availability of labour, sowing is delayed, which leads to reduction in yield. Thus, to introduce cultivation of garlic, there is need of an efficient animal drawn garlic planter suitable for small and marginal farmers.

2. Material and Methods

The equipment components were manufactured using standard raw materials, after preparing computer aided drawing. The animal drawn equipment for garlic sowing was developed after prototype production and later it was tested under laboratory and field conditions as per standard procedure. The prevailing sowing practice and difficulties faced by garlic growers in sowing were taken in to consideration for designing new unit which ensured use of recommended seed rate, predetermined depth, desired row and plant spacing, seed cut-off, no mechanical damage, permissible inter row variation and seed missing ease in operation and adjustments.

Selection of Metering Mechanisms

Three types of metering mechanisms (MM) *viz.* commercially available cell type metering mechanism (MM1), commercially available spoon type metering mechanism (MM2) and cup type based new developed metering mechanism (MM3) were selected for this study. The specifications of these metering mechanisms are given in Table 1. Critical dimensions for designing the cells for these metering mechanisms were finalized considering the dimensions and geometry of garlic cloves. Three different metering boxes were fabricated for housing the metering mechanisms.

Table 1. Specifications of the selected metering mechanisms

Particulars	Cell type (MM1)	Spoon Type (MM2)	Cup Type (MM3)
No. of cells	8	12	8
Diameter of roller, mm	197	195	217
Width of groove of cell, mm	48	21	18
Length of groove of cell, mm	40	32	28
Depth of groove of cell, mm	21	12	22

Testing of metering mechanisms in the laboratory

A sticky belt set-up consisting of two rollers (300 mm diameter each) mounted on a stand at a distance of 1000 mm; having speed variability between 0 to 5 km.h^{-1} was used for laboratory test. The belt was besmeared with grease to secure the seeds to fall on belt surface, without bouncing or rolling. Linear speed of conveyor belt was measured by an ultrasonic sensor which was recorded by micro-logger. The seed metering mechanism was positioned over the belt by placing its drive wheel on the surface of the moving belt that provided transmission by resistance to the shaft of metering mechanism. Distribution of seeds dropping on the sticky belt was measured for seed spacing for each metering mechanism. The sticky belt set-up with cell type, spoon types and cup type metering mechanisms is shown in Fig. 1.

(a) Cell type (b) Spoon type (c) Cup type

Figure 1. Metering mechanisms with metering boxes on sticky belt test set-up

Metering rollers were powered by ground drive wheel, which revolved on rubber conveyor belt against friction. The metering mechanism was driven by ground wheel using sprocket and chain transmission. The plant spacing could be varied by changing the sprocket with higher or lower numbers of teeth. Suitability of sprocket on metering shaft was calculated using equation given below to get the desired plant spacing.

$T_{me} = P \times N_c \times T_{ma} \times (0.314 \times D_g)^{-1}$ ………..… (1)

Where T_{me} = number of teeth required on metering shaft, P = Plant spacing (mm), N_c = no. of cell on metering roller, T_{ma} = number of teeth on main shaft, D_g = Diameter of ground drive wheel.

The set of sprockets required for the desired seed to seed spacing were calculated using equ. (1) and found to be 16 or 17 and 21 or 22 for MM1/MM3 and MM2, respectively. Different parameter such as Miss Index, Multiple Index, Quality of feed Index and Precision Index were calculated at three speeds 1.5, 2.0 and 2.5 km/h with three replications for selected metering mechanism for garlic planter.

Draft Prediction and measurement of actual draft

The required draft at different depths calculated are shown in Table 2. The required draft of machine ranged from 900 to1350 N with increase in depth of operation from 20 to 30 mm. The average actual draft was found to be 450 N for animal drawn three rows garlic planter at 25–35 mm depth of operation. The results indicated that predictions of draft by ASABE model are on higher side in the case of this machine.

Table 2. Required draft and power at different depths

F1	A	B	C	Depth, mm	Draft, N
1	900	0	0	20.0	900
				25.0	1125
				30.0	1350

Fabrication of Animal Drawn Three Row Garlic Planter

Three row garlic planter with cup type metering mechanism suitable for Malvi and local breeds of bullocks of Madhya Pradesh was designed and developed. The technical specification of the planter is shown in Table 3**.** The planter was also equipped with fluted roller metering mechanism for simultaneous application of fertilizer. The height of seed drop was kept the lowest possible at 300 mm to minimize negative velocity to the garlic clove which affected seeding uniformity. Each metering mechanism got drive from ground wheel through chain and sprocket. Average draft requirement of the implement was 450 N and actual field capacity was 0.1 $ha.h^{-1}$ with 70% field efficiency. Height of hopper box was adjusted with the help of lifting rod handle assembly to control the quantity of cloves in metering box. The operation of animal drawn three rows garlic planter in operation is shown in Fig. 2.

Table 3. Specifications of animal drawn three row garlic planter

Particulars	Value
Overall dimensions (Length x Width X height), mm	950 x 970 x 920
Weight, kg	50
Working width, mm	450
Working depth, mm	30
Operating speed, km/h	2.3
Field capacity, ha/h	0.10
Field efficiency, %	70
Average draft, N	450
Labour requirement, man-h/ha	14

Garlic seeds were sown with the help of all three metering mechanisms at research field of Central Institute of Agricultural Engineering, Bhopal, India (*Rabi* season). Field experimentation was carried out for all selected metering mechanisms. Sowing length 40 m, six rows with row to row spacing of 150 mm and plant to plant of 100 mm. Seeds germination with different metering mechanisms was recorded. Three garlic planted rows were selected randomly after 30 days of germination for different metering mechanisms for the purpose of measuring seed spacing and number of seeds per drop. Different parameters like average seed spacing, Miss Index, Multiple Index, Precision Index were calculated. Operational speed and draft were also recorded for animal drawn garlic planter with each metering mechanism. Measurement of average seed spacing, miss index, multiple index, quality of feed index, Precision Index and percentage of occurrence of single, double and multiple seeds were determined under field conditions. Sowing was carried out in experimental plots with three rows for each metering mechanism with three replications

3. Results and Discussion

Under laboratory test, the maximum and minimum average seed spacing were found to be 127.8 mm (SD=±56.4 mm) at speed 2.5 km.h^{-1} in the case of MM1 and 88.1 mm (SD= ±53.4 mm) at speed 1.5 km.h^{-1} in MM2, respectively at targeted seed spacing of 100 mm. The seed spacing of MM3 was found to be 102.1 mm (SD= ±47.8 mm) at 2.5 km.h^{-1}. The maximum miss index was found to be 17.75% at speed 2.5 km.h^{-1} in the case of MM2 and minimum was 8.72% in the case of MM3. The higher miss index was found in MM2 may be due to inability to pick up garlic clove at higher speed. The highest multiple index was found to be 16.73% with MM1 at a speed of 2.5 km.h^{-1} and minimum was 6.48% with MM3 at km.h^{-1}. Maximum multiple index was found with cell type metering mechanism. It was due to that the cloves rolled through the space between the metering rollers. Minimum feed index was 71 % at a speed of 1.5 km.h^{-1} in the case of MM1 and maximum of 84.8% at 2.5 km.h^{-1} in the case of MM3. Maximum precision index was found in the case of MM2 (26.03%) and minimum in the case of MM3 (21.78%). Maximum percentage of occurrence of one seed drop was 81.56% at a speed of 2.5 km.h^{-1} in the case of MM3 and minimum was 61.37% in the case of MM3 at the same speed. Maximum percentage of occurrence of dropping of two seeds was found to be 33.87% at a speed of 2.5 km.h^{-1} in MM3 and minimum was 16.15 % in the case of MM1 at the same speed. Multiple seed drop (no. of seeds > 2) was maximum with MM2 and minimum with MM1 at 1.5 km.h^{-1}. Overall seed damage was in the range of 2–4%. Under field conditions, speed of operation of bullock ranged 2.2-2.5 km.h^{-1}. Average seed spacing of MM3 was 108.7 ±40.10 mm as compared to targeted seed spacing of 100 mm. Maximum and minimum Miss Index were 17.23% and 10.23% for MM2 and MM3, respectively. Maximum multiple index was 15.26% for MM1 and followed by 11.92% for MM2 and 7.45% for MM3. Maximum feed index was 82.32% in the case of MM3 and minimum of 70.50% in the case of MM1. Maximum precision index was 24.33% in the case of MM2 and minimum of 22.04 % in the case of MM3. Maximum percentage of occurrence of single seed drop was 84.43% for of cup type and minimum of 78.55% for of cell type metering mechanisms. Maximum percentage of occurrence of two seeds drop was 16.74% in the case of MM3 and minimum of 13.32% in the case of MM1. Multiple seed drop (no. of seeds > 2) was maximum in the case of MM1 and minimum in MM2.

The cost of machinery operation was done as per Indian Standard Institute (1979, Reaffirmed 2002) standard. The depreciation and interest rate were taken as 10% of initial cost of the planter. The planter cost was fixed at Rs 10,000. The useful life of the planter was considered as 2,000 h. considering total life 10 year and operational hour 200 per year. The wage cost was considered as Rs 37.5 hour^{-1} and the hourly cost of one pair of bullock was taken as Rs 55.00 hour^{-1}.

The labour requirement for animal drawn garlic planter was found to be 14 man-h.ha^{-1} as compared to 200 man-h.ha^{-1} for manual planting. The cost of planting using animal drawn garlic planter was Rs 1432 hectare^{-1} as compared to Rs 7500 ha^{-1} in the case of manual planting. Therefore, the planter saved 80% of cost as compared with manual method. Other operational costs including land preparation, intercultural operation, and chemical application were considered the same for both methods at Rs 5000 ha^{-1}. It is seen from Table 4 that the difference in net profit is very low but garlic planter ensures timeliness of operation.

The garlic planter saved more than 90% of the time as compared to manual methods and the farmer can benefit by utilizing his time for other activities.

Table 4. Comparison of cost between manual planting and improved planter

Particulars	**Garlic planter**	**Manual planting**
Seed rate, kg/ha	600	600
Cost of seed, Rs/kg	35	35
Cost of seed, Rs/ha	21000	21000
Operational cost of sowing, Rs/ha	1432	7500
Other operational cost, Rs/ha	5000	5000
Input cost, Rs/ha	27432	33500
Yield, kg/ha	6700	7000
Market rate of garlic, Rs/kg	20	20
Total output, Rs/ha	134000	140000
Net profit, Rs/ha	106568	106500

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