

Full Length Research Paper

Performance evaluation of a tractor mounted pneumatic planter for sorghum in dryland

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Performance of a pneumatic planter was studied in both laboratory and actual field conditions using sorghum seeds in context to justify its use in dry land. Pneumatic planter consists of frame, aspirator blower, seed hopper, metering unit, multi-groove metering plate, vacuum retaining plate, furrow opener, pair of ground wheels with power transmission system. The multi groove metering plate having seed hole of diameter 3 mm and vacuum pressure of 2 kPa were used throughout the experiments for picking of single seed. Based on the results of laboratory tests the performance of the pneumatic planter was carried out in field. Data on performance parameters of the pneumatic planter was collected, analyzed and found that, average values of plant to plant spacing, miss index and multiple index, actual field capacity and field efficiency were found to be 101 mm, 2.07%, 3.8%, 0.773 ha/h and 79.7%, respectively.

Key words: Pneumatic planter, sorghum, seed rate, performance indices.

INTRODUCTION

Horizontal seed metering devices were popular and widely accepted but the problems occurred with higher seed damage, missing and multiple drops. To reduce these losses, inclined and vertical plate planters were developed (Shafii and Holmes, 1990; Guarella et al., 1996). Horizontal plate planters with cells on the periphery, as a seed metering devices for precision planting of seeds were the first precision planters developed in India (Datta, 1974). Literature reveals that the difficulty was felt with developed planters to plant irregular and spherical shaped seeds. Therefore,

pneumatic metering devices were tried which has the advantage of metering irregular shaped seeds, besides spherical seeds. Pneumatic planting devices could be suitable for planting of groundnut, cotton, sorghum, maize, soybean, sorghum, mustard, okra and radish but its use has to be justified by conducting the field experiments.

Use of conventional seeding devices has higher seed rate application which leads to wastage of costly seeds, adds the cost of thinning and results in increased production cost. Dixit et al. (2011) compared the

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Figure 1. Pneumatic planter during in laboratory evaluation. 1. Frame; 2. Aspirator blower; 3. Seed hopper; 4. Metering unit; 5. Multi groove metering plate; 6. Vacuum retaining plate; 7. Furrow opener; 8. Ground wheel; 9. Cordon shaft.

performance of inclined plate planter and pneumatic planter and found that pneumatic planter performed much better for cotton. Using pneumatic planter, seed germination efficiency has increased many folds at reduced seed rate compare to conventional planters. Inter row and intra row spacing for sorghum is an important factor in order to achieve optimum crop yield. The parameters for the evaluation of performance of the planter include spacing between seeds or plants (Hollewell, 1992; Parish et al., 1991), percent multiples and misses (Brooks and Church, 1987; Singh et al., 2005; Singh et al., 2007; Sun et al., 2012; yasir et al., 2012) and precision in spacing (Hofman, 1988; Jasa and Dickey, 1982). Important factor of the pneumatic seed-metering device is its uniformity of seed spacing. Besides the design of the metering devices, field and operational parameters affect the precision distribution of seeds.

Karayel and Ozmerzi (2001) stated that variability in the seed spacing with a precision vacuum seeder increased with increasing forward speed. Use of conventional planting machines does not maintain precise plant spacing and seed rate (Khambalkar et al., 2014). Therefore, an attempt was made to evaluate the pneumatic planter developed at CIAE (Central Institute of Agricultural Engineering), Bhopal both in laboratory and field conditions to justify its use in planting of sorghum

seeds in dry land cultivation of sorghum.

MATERIALS AND METHODS

The pneumatic planter consists of main frame, aspirator blower, disc with cell type metering plate, individual hopper, furrow openers, PTO driven shaft, ground drive wheel etc. Pictorial view of the pneumatic planter is shown in Figure 1. Specifications of the pneumatic planter are given in Table 1.

Power transmission system of the pneumatic planter

Power transmission system with different gear arrangement of the pneumatic planter is shown in the Figure 2. Various gear ratios were used to get desired seed rate. Two gears were mounted on the axle of the ground wheel having 14 and 20 teeth. The power from the ground wheel was then transferred through chain to the primary driving shaft having gears with 20 and 14 teeth at each ends. The primary driving shaft had five gears 26, 22, 20, 16 and 14 in first, second, third, fourth and fifth, respectively. The power from primary driving shaft is transferred to the secondary driving shaft with the help of chain and idler gears. Seven idle gears were of 14 teeth in the secondary driving shaft. One gear on the secondary driving shaft is connected to one of the five gears on the primary driving shaft through chain. The power from the secondary driving shaft is transferred to the seed metering plate. The other gears on the secondary driving shaft were attached to the gear on the axle of seed metering device with the help of chain. The gears on the seed

Table 1. Specifications of the pneumatic planter.

Parameter	Value
Overall dimensions, mm	1450 × 2450 × 1250
Weight, kg	200
Number of rows	6
Row spacing, mm	250 and above
Type of blower	Aspirator
Seed metering	Pneumatic disc suction principle
Change of seed spacing	By changing appropriate size of sprocket
Number of holes on disc	16
Seed hole diameter, mm	3
Working width, mm	2700
Power source	Tractor 25 kW and above

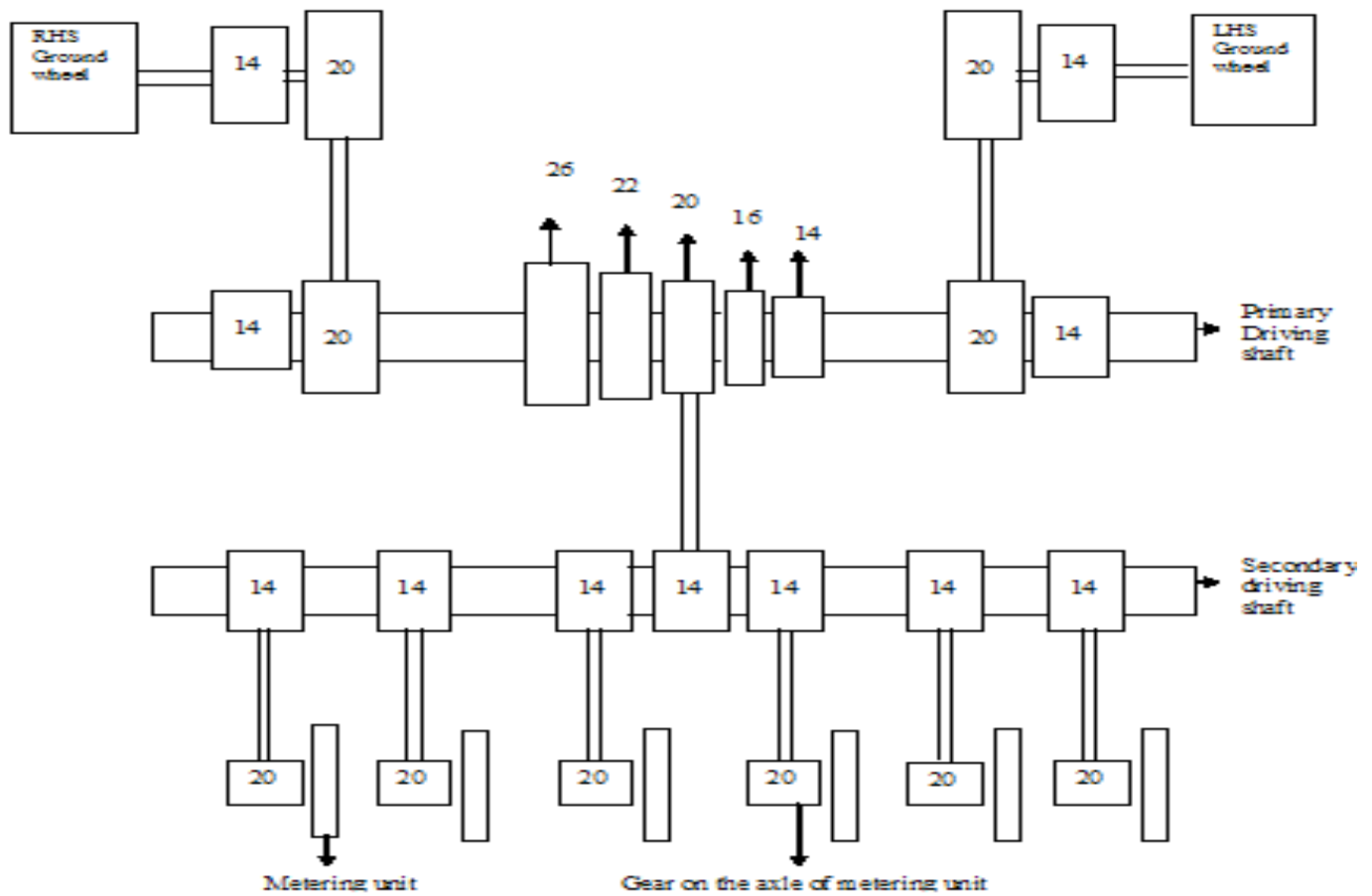


Figure 2. Power transmission system of the pneumatic planter.

metering mechanism had 20 teeth, as shown in Figure 1.

Working principle of pneumatic planter

The metering device was powered by a pair of ground wheels

through chain and sprocket. Power to the aspirator blower was given by PTO shaft of the tractor with the help of cordon shaft. The disc was mounted to a vacuum retaining plate made of Bakelite material having outer diameter 295 mm and thickness 40 mm. Suction pressures inside the metering unit was created by connecting it to a vacuum pump. The vacuum retaining plate was

Table 2. Parameters and their values of field, seed and operational parameters.

Parameter	Value
Plot size, m ²	24 m × 12 m
Type of soil	Sandy clay loam
Moisture content, %	9±2
Bulk density, g/cc	1.31±0.05
Forward speed, km/h	3.2-3.6
Slip of driving wheels, %	8-10
Row to row spacing, mm	450
Seed to seed spacing, mm	100 ± 5
Depth of placement of seed, mm	30 ± 5

equipped with a baffle to release the vacuum pressure of the seed disc. The rotating seed disc carried the seeds attached to the seed holes under negative pressure and dropped only when the holes passed through the baffle that released the suction pressure. The dropped seed fall in the furrow opened by furrow opener and cover with the soil. To view the movement of the seeds inside the metering disc, the seed disc was provided with a protective cover made of mild steel and transparent acrylic plastic.

Laboratory evaluations

The pneumatic planter was calibrated with sorghum seeds in the laboratory. PTO was connected to the aspirator air blower of the pneumatic planter. The gear combination at left and right hand side of ground wheel was set and the main driving shaft of gear was laid on the first gear. Then the PTO was operated at 550 rpm resulting in the rotation of the blower at 2720 rpm to create proper vacuum in the seed metering unit for proper metering of the seed. Then the ground wheel of the pneumatic planter was rotated 20 times with constant speed manually. Seeds were collected in the polyethylene bag underlying the furrow opener. Simultaneously the rpm of PTO shaft was taken by the tachometer to about 550 rpm. The seed quantity was measured in grams. Similar procedure was adopted for the different gears of main driving shaft at same setting of side gears of ground wheel. The side gear combination of ground wheel was changed and again the observations were taken at different gears of main driving shaft as stated earlier. Three replications were taken for each setting and average values are given Table 2.

Performance parameters measured during field evaluation

Speed of operation

The time taken (s) to distance travelled (m) during operation was determined using stopwatch. The forward speed of tractor (km/h) was calculated by following equation.

$$\text{Forward speed of tractor} = \frac{\text{Distance}}{\text{time}} \times 3.6 \quad (1)$$

Field capacity and field efficiency

The actual field capacity, theoretical field capacity and field efficiency was calculated as follows:

$$AFC = \frac{Ac}{Tt} \quad (2)$$

$$TFC = \frac{W \times S}{10} \quad (3)$$

$$FC = \frac{AFC}{TFC} \times 100 \quad (4)$$

Where AFC = actual field capacity (ha/h), TFC = theoretical field capacity (ha/h), Ac = actual area covered (ha), Tt = time taken (hr), FC = field efficiency (%), W = width of machine (m), and S = forward speed (km/h).

Miss index

The miss index (I_{ms}) is the ratio of number of spacing (N_{ms}) greater than 1.5 times of set spacing and total number of measured spacings (N):

$$I_{ms} = \frac{N_{ms}}{N} \times 100 \quad (5)$$

Multiple index

The multiple index (I_{mt}) is the ratio of number of spacing (N_{mt}) ≤ 0.5 times of set spacing and total number of measured spacings (N):

$$I_{mt} = \frac{N_{mt}}{N} \times 100 \quad (6)$$

Pneumatic planter was set based on the results obtained in laboratory. The procedure outlined in RNAM Test code and procedure (1983) for seedling equipment was followed. Parameters and their values of field, seed and operational parameters is shown in Table 2.

The pneumatic planter was powered by 29.84 kW tractor (TAFE 585 DI). The tractor was operated at an average forward speed of 3.6 km/h. Pre-experimental trials had been undertaken to adjust the working parts such as speed of PTO shaft, furrow openers, depth adjustment. A mark was made on the lever of the three point linkage to set the depth of operation of the furrow opener at 30 mm. Pneumatic planter during field operation is shown in Figure 3.



Figure 3. Pneumatic planter during actual field operation.

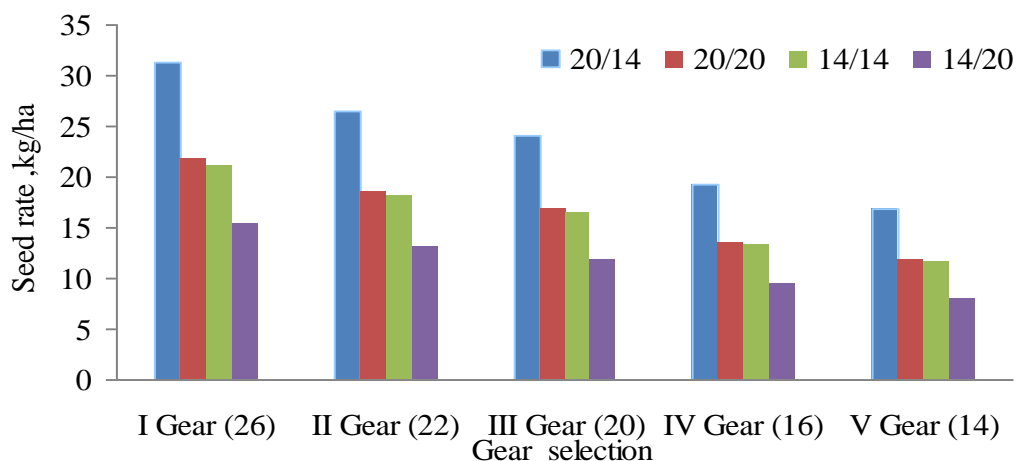


Figure 4. Sorghum seed rate obtained at different gear combinations.

RESULTS AND DISCUSSION

The pneumatic planter was tested in the laboratory as well as in field conditions of Department of Farm Machinery and Power Engineering and Crop Research Center of GBPUA and T Pantnagar, respectively. The tests were carried out for sorghum seeds at different gear combinations to obtain the recommended seed rate. The seed rate obtained for different combination and for different gears of primary driving shaft is shown in the Figure 4.

Gear having 14 teeth mounted on the axle of ground wheel is attached to the gear having 20 teeth mounted at

the ends of the primary driving shaft, and second gear, that is, having 14 teeth mounted on the middle of the primary driving shaft gives the required seed rate of 7.98 kg/ha and was within the recommended seed rate of 7.5 to 8 kg/ha. Based on the results obtained in laboratory, performance of the pneumatic planter was carried out in field. Data on performance parameters of the planter such as the plant to plant spacing, miss index and multiple index, actual field capacity and field efficiency was collected and analyzed. The average values of the field trials conducted were found as 101 mm, 2.07%, 3.8%, 0.773 ha/h, 79.7%, respectively. The average values of all the performance parameters are given in

Table 3. Average values of all the performance parameters.

Parameter	Plot 1	Plot 2	Plot 3	Average
Plant spacing, mm	100.35	99.98	102.28	100.87
Miss index, %	1.99	2.10	2.13	2.07
Multiple index, %	3.8	3.9	3.7	3.8
Field capacity, ha/h	0.775	0.785	0.760	0.773
Field efficiency, %	80	81	78	79.7

Table 3. Standard deviation and standard error was 5.8, 3.4, 9.2 and 1.7, 0.7, 1.5 for miss index, multiple index and field capacity respectively.

Conclusions

The pneumatic planter was found suitable for sorghum with the best suited gear combination, that is, gear having 14 teeth mounted on the axle of ground wheel and 20 gear teeth mounted at the ends of the primary driving shaft with 14 gear teeth mounted at the middle of the primary driving shaft of pneumatic planter with tractor PTO shaft speed of 550 rpm. Performance of the pneumatic planter was evaluated in the field and the average values of plant to plant spacings, mean miss index and multiple index, actual field capacity and field efficiency were found to be 101 mm, 2.07%, 3.8%, 0.77 ha/h, 79.7%, respectively. All the observed values were within the recommended levels. Hence, this planter was found suitable for planting of sorghum seeds in dry land.

Conflict of Interest

The authors have not declared any conflict of interest.

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