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RESEARCH ARTICLE

Performance evalution of pneumatic planter using pigeonpea seeds

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ABSTRACT : The performance of a pneumatic planter was carried out in laboratory with an objective of selecting the required gear ratio for obtaining recommended seed rate of pigeonpea. Based on the results of laboratory tests the performance of the pneumatic planter was carried out in field. Pneumatic planter consisted of frame, aspirator blower, seed hopper, metering unit, multi groove metering plate, vacuum retaining plate, furrow opener, pair of ground wheel with transmission system. For picking single seed, the multi groove metering plate having seed hole of diameter 3 mm and vacuum pressure of 2 kPa were used throughout the experiments. 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 101.1 mm, 1.5 per cent, 3.5 per cent, 0.953 ha/h, 88 per cent, respectively.

KEY WORDS : Pneumatic planter, Pigeonpea, Seed rate, Performance indices

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INTRODUCTION

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). 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 plates planters were developed, moreover the pneumatic seed-metering device and used (Shafii and Holmes, 1990; Guarella *et al.*, 1996). Pnematic metering device has the advantage of metering irregular shaped seeds, besides spherical seeds. Such devices could be suitable for planting of groundnut, cotton, pigeonpea, maize, soybean, sorghum, mustard, okra and radish but its use has to be justified by conducting the field experiments.

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Use of conventional seeding devices have higher seed rate application which leads to wastage of costly seeds and adds the cost of thinning results in increases the production cost. Using pneumatic planter, seed germination efficiency has increased many folds at reduced seed rate compared with conventional planters. Inter row and intra row spacing for pigeonpea 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), per cent multiples and misses (Brooks and Church, 1987) and precision in spacing index (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. Therefore, an attempt was made to evaluate the pneumatic planter developed at CIAE (Central Institute of Agricultural Engineering), Bhopal in laboratory and field conditions to justify its use in planting of pigeon pea seeds.

EXPERIMENTAL PROCEDURE

Components of the pneumatic planter :

The pneumatic planter consisted of main frame, aspirator blower, disc with cell type metering plate, individual hopper, furrow openers, PTO driven shaft, ground drive wheel etc.

Frame :

The frame of the planter was fabricated by welding the angle iron of size 70 x 70 x 5 mm pieces to form a rectangular frame of size 450 x 3050 mm. It was a common platform to mount all the components of the planter.

Aspirator blower :

An impeller rotates inside a casing, draws in the air at its centre (eye) and throws out the air through an opening at the side of the casing. Aspirator blower suck the air from the plate chamber and create vacuum in the metering unit due to which seed stick on the plate and is released when the vacuum pressure is cut off. It was operated by the PTO of the tractor.

Disc with metering plate :

A modular pneumatic seed-metering system having a disc of outer diameter 280 mm and thickness 7 mm with equidistant holes was used. Seed spacing was regulated by changing the rotational speed of metering disc. There were 16 numbers of holes/cells on the metering disc.

Furrow opener :

Inverted T type furrow opener was provided with each modular unit. Six furrow openers were used to form a six row planter.

Seed hopper :

The capacity of seed hopper was about 8-15 kg and provided with each furrow.

Ground wheel :

The ground wheel of diameter was 470 mm. six lugs were welded at outer periphery of the wheel at equal radial spacing. Six spokes were welded at inner periphery of wheel at an angle of 60°.

Working of the 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 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.

Power transmission system of the pneumatic planter :

Power transmission system with different gear arrangement of the pneumatic planter is shown in the Fig. A. 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 is 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 idler 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 metering mechanism have 20 teeth, as shown in Fig. A.

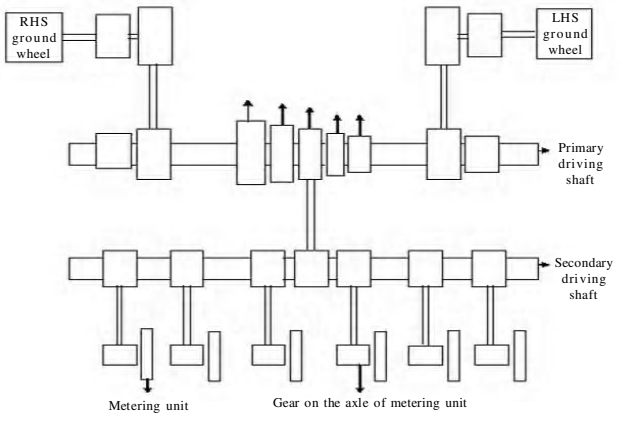

Fig. A: Power transmission system of the pneumatic planter

Laboratory evaluations :

The pneumatic planter was calibrated pigeonpea seeds in the laboratory. The tractor 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. The different seeds were col1ected on the poly-ethylene sheets underlying the furrow opener. Simultaneously the rpm of PTO shaft was taken by the tachometer to about 550 rpm. The seed quantity and number of seeds in the col1ection sheets were measured individually for each seed. Pneumatic planter during in laboratory evaluation is shown in Fig. B.

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

Fig. B: Pneumatic planter during in laboratory evaluation

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. For adjustment of gear there was a lever given near the seed hopper which loosens the idler gear and by this the gear of primary driving shaft could be easily changed.

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.

$$\text{Forward speed of tractor} = \frac{\text{Distance}}{\text{time}} \text{ x } 3.6$$

Field capacity and field efficiency :

The actual field capacity, theoretical field capacity and field efficiency of the MAVT were calculated as follows :

$$AFC = \frac{Ac}{Tt} \quad TFC = \frac{WxS}{10} \quad FC = \frac{AFC}{TFC} x100$$

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), S= forward speed (km/h)

Miss index :

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

$$1_{ms} = \frac{N_{ms}}{N} x100$$

Multiple index :

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

$$1_{mt} = \frac{N_{mt}}{N} x100$$

Field performance of the pneumatic planter was evaluated for pigeonpea seeds at 50 × 10 cm spacing in three well prepared plots each of 30 × 15 m size. The soil moisture content was 9.0±2% (db). Pneumatic planter was set according to the observations obtained in laboratory evaluations. The procedure outlined in RNAM Test code and procedure (1983) for seedling equipment was followed. The pneumatic planter was powered by 40 hp 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 filed operation is shown in Fig. C.

Fig. C : Pneumatic planter during field operation

EXPERIMENTAL FINDINGS AND ANALYSIS

The pneumatic planter was tested in the laboratory as well as in field conditions of Department of Farm Machinery

Table 1 : Pigeon pea seed rate obtained at different gear combinations

Gears on primary driving shaft	Gear combinations between ground wheel and main driving shaft			
	20/14	20/20	14/14	14/20
I[st] Gear (26)	31.28	21.91	21.02	15.38
II[nd] Gear (22)	26.44	18.54	18.11	13.12
III[rd] Gear (20)	24.12	16.85	16.44	11.79
IV[th] Gear (16)	19.27	13.48	13.33	9.37
V[th] Gear (14)	16.85	11.79	11.60	8.21

and Power Engineering and Crop Research Center of GBPUA and T Pantnagar, respectively. The tests were carried out for pigeonpea crop at different gear combinations to obtain the recommended seed rate. The seed rate of pigeonpea obtained for different combination and for different gears of primary driving shaft is shown in the Table 1.

It is revealed from the Table 1 that the fourth combination *i.e.* 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 *i.e.* having 22 teeth mounted on the middle of the primary driving shaft give the required seed rate of 13kg/ha and was within the recommended seed rate of 12-15kg/ha. The aspirator blower was operated at PTO shaft speed of 550 rpm.

Similarly, based on the results of laboratory tests the performance of the pneumatic planter was carried out in field. Performance parameters of the planter such as the plant to plant spacings, mean miss index and multiple index, actual field capacity and field efficiency were determined. The average values of the field trials conducted were found as 101.1 mm, 1.5 per cent, 3.5 per cent, 0.953 ha/h, 88 per cent, respectively.

Conclusion :

The pneumatic planter was found suitable for pigeonpea with the best suited gear combination *i.e.* 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 22 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 101.1 mm, 1.5 per cent, 3.5 per cent, 0.953 ha/h, 88 per cent, respectively. All the observed values were within the recommended levels. Hence, this planter was found suitable for planting of pigeonpea seeds.

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