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Performance of tractor operated horizontal rotor plate planter

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■ **ABSTRACT :** In rainfed conditions the success of crop production depends on timely seeding. The seed rate for various dryland crops varies from 4 to 140 kg/ha. Availability of a multi crop planter with replaceable metering plate is crucial to meet the seed rate requirements and to reduce the cost involved in machinery management. Though different types of planters having different seed metering mechanisms were evolved, their performance is not up to the mark. Hence, a horizontal rotor seed metering plate mechanism was developed and tested both under laboratory (2.5,3.5 and 5km/h speeds) and field conditions. The mean number of seeds metered at different forward speeds for maize and castor crop varied from 184.8 to 192.6; 185.8 to187.6, respectively when compared to theoretical metered seeds of 180. The quality of feed index of the planter ranged from 85 to 90.5 per cent and 82.7 to 97 per cent, clearly indicated the frequency distribution of seeds with in space intervals > 10 to < 30 cm. The horizontal rotor metered 85 – 93 frequency percentile seeds within 15 – 30 cm spacing intervals at operation speeds of 2.5 to 3.5km/h. At average field speeds of 2 and 3.5km/h, 70 and 65 per cent of the seeds were sown, respectively in a spacing interval of 15 – 30cm, which also indicated the higher quality of feed index for the developed planter.

■ **KEY WORDS :** Horizontal rotor plate, Planter, Quality of feed index, Field testing

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Agriculture is one of the most important sectors of Indian economy both in terms of gross national product and number of productive workers employed. Out of 142.6 million hectares of net cultivated area in the country,55 per cent is under rainfed agriculture, which contributes 30 per cent of the food grains. Mechanization of agriculture necessitates use of appropriate machinery to increase the inputs use efficiency. In rainfed farming conditions numerous crops being grown and the success of crop production depends on timely seeding of crops with reduced in drudgery of farm labour. The seed rate for various rainfed crops varies from 4 to 140 kg/ha. Until recent past, the crops are generally sown manually by drilling behind the plough or dibbling and later thinning is performed to maintain optimum plant population, which is quite labour intensive operation.

In crop production for higher productivity, it is essential for seeds to be placed at equal intervals within rows. In manual sowing practice, the higher and non-uniform plant population adversely affected grain yield in pearl millet, cluster bean, moth bean and green gram crops (Singh *et al.*, 2007). Effect of plant spacing uniformity on sunflower yield in Minnesota was determined by Robinson *et al.* (1982).Uniformly spaced single plants lodged the least, gave the greatest seed yield and contained greatest oil content. The ultimate objective of seed planting using improved planting equipment is to achieve precise seed distribution within the row. Jasa and Dickey (1982) concluded that tillage system has minimal effect on seed spacing uniformity of corn planted using seed planter.

The fluted roller type seed metering device is very popular in India. However, this mechanism is very much suitable for small seeds which are drilled at low plant to plant spacing in a row. Although many planters having different seed metering mechanisms *i.e.* inclined plate, cup feed type and roller with cells on periphery for the application of single seed at a time has been developed, their performance is not up to the mark due to non performance in obtaining required spacing for crops like sunflower, okra, maize, groundnut and green gram (Chauhan *et al.*,1999; Sahoo and Srivastava, 2000; Dhalin *et al.*, 2004 and Singh *et al.*, 2006). Never the less, demand for the single seed metered planters is increasing rapidly due to the fact that, it saves cost on seed to be applied and there after labour cost to carry thinning operation to obtain optimum plant stand. At the same time, the same planter mechanism could be utilized for various rainfed crops just by changing seed rotor only with minor modifications. The achievement of the set seed rate and spacing majorly depends on the machine technical variables such as the type of seed rotor mechanism, the machine operating speed, overall gear ratio between drive wheel and seed rotor and up to some extent on seed quality. Thus, for reasonably improved productivity, the metering mechanism should be accurate enough to plant seeds to the required seed distance on a row. So, studies on new rotor metering mechanism will help in developing a multi crop planter for various crops and enhancing the productivity.

Keeping the above aspects in view, at Central Research Institute for Dryland Agriculture, Hyderabad, the present study was undertaken with objectives to study the design parameters for a horizontal rotor plate planter metering mechanism, evaluate in the laboratory using a running belt test rig for maize and castor and with maize seed under field conditions.

METHODOLOGY

Development of horizontal rotor plate mechanism :

The mechanism consisted of three circular shape cast mild steel plates placed one over the other. The lower base plate (210 mm outer and 120mm inner diameter) was cup shaped with a central cut strip and fixer holes to keep the metering rotor in horizontal position and obtain rotary motion. An oblong shape slot on one edge of cup and a locking latch on the opposite side match the centre line of the strip. Perpendicular to the strip, two 30mm diameter circular collars are provided at lower edge to arrange the drive shaft with bushes. The middle portion of the mechanism is a simple circular shape ring with 25mm wide strip made out of mild steel plate with a 20x20mm size hole. The upper portion of the mechanism is also in circular ring shaped with 250mm outer diameter and 35mm width strip made of mild steel through casting technique. The central portion of this part is covered with 140mm diameter circular cut portion to which 5mm thick wall collar bush of 20mm inner diameter was provided at the centre lower side to facilitate for drive transfer to seed plate. The central cut part is slightly tapered towards the outer edge due to which very closely in contact with seed metering plate. The central collar bush is designed such a way that, the central portion of the seed metering plate could be kept thicker to avoid shear way due to rotational movement and thin at the cells portion to avoid multiple seed pick up in operation. This type of arrangement also facilitates to use the same metering mechanism for different types of seeds by just changing the seed plate. A circular hopper of 230mm diameter with 300mm height made of fiber plastic was fitted over the top portion of the mechanism to keep the seeds. The spatial dimensions of the promising maize and castor verities were measured and the dimensions of cells and peripheral speed of rotor plate optimized using a grease belt test rig (Table A).

Fabrication of test rig :

A grease belt test rig that provides an environment for the determination of seed rate and seed placement of selected metering mechanism was developed to carry the tests in the laboratory conditions. The test rig consisted of a rectangular frame of 400x60 cm made of 35x35x5 mm M S angle iron. Eight legs of 60 cm length welded to the frame to give stability and proper ground clearance for work place. Two rollers of 41 cm length and 11 cm diameter were fabricated and fitted over the frame using pedestal bearings at 280 cm apart to run the grease belt. The distance between the two rollers is adjustable in 25 mm increments to tighten the belt when required. To fit different seed planter metering boxes for testing, a 90 cm height and 60x40cm rectangular frame made of angle iron was fabricated and fitted near the drive roller. The drive transmission from the motor to the drive roller of endless belt and feed shaft is through sprocket and chain at speed ratio of 1:1. A 5hp and 2hp electrical motors fitted with variable frequency speed drives run drive roller and seed metering feed shaft respectively. The variable speeds are obtained by variable frequency drive regulator, which in-turn changes the in-put voltage to the motors. A specially fabricated 2.5 mm thick poly vinyl chloride impregnated with nylon material non expandable single side grip flexible endless belt was used in the test rig. A

Table A: Specifications of optimized horizontal rotor plate metering mechanism

Parameters	Horizontal plate mechanism
Seed box shape and dimensions	Circular, D = 25.5cm
Material used for seed plate	Poly vinyl chloride
Seed plate shape, diameter and thickness	Circular, d = 194mm t = 6mm
Seed cells shape and no. of cell on plate	Circular, 24 Nos
Target seed spacing for maize and castor	20 cm
Mean seed cell size	
Maize	58.27 sq.mm, (C.V. = 3.835)
Castor	89.22sq.mm, (C.V. = 6.819)
Over all gear ratio from ground wheel to seed plate rotor	4 :1

thin layer of grease was applied to the belt so as to capture the seeds without any displacement.

Evaluation of metering mechanism of planter :

The horizontal plate planter metering mechanism was evaluated for its seed dropping quality and plant spacing in the row, using the grease belt test rig in the year 2011- 2012. The planter mechanism was run five times for each experiment at selected forward speeds of 2.5, 3.5 and 5km/h. In the first test runs, after seed metering shaft reached to steady state condition, it allowed to run 30 revolutions and the seed metered was collected, counted manually and seed damage if any was also noted. In the second test runs the planter seed metering rotor and grease belt were started and run for 120sec to reach steady state operating conditions. Once the steady state reached, the seeds were allowed to fall on the marked portion of grease belt. As soon as the seed is captured by the greased portion of the belt, the grease belt and planter were stopped manually as quickly as possible. A tape was stretched out besides the seeds on the grease belt and the seed to seed spacing locations determined. The data thus obtained were tabulated and analyzed for frequency distribution as for the criteria suggested by Kachman and Smith (1995) as appropriate measures to draw valid conclusions.

Horizontal plate planter development :

Horizontal plate planter consists of (i) Main frame (ii) Seed hoppers with horizontal rotary plate metering mechanism (iii) Furrow openers (iv)Drive transmission. The planter main frame is rectangular in shape made of mild steel L - angle sections of size 60 x 60 x 6 mm welded two pieces together to form a hallow square bar. The size of the frame is 2.30 x 0.75 m. Holes of 12 mm diameter were drilled at 65 cm apart along the length and width of the frame to mount a fixer frame made of 25 x 4 mm L- angle for arranging the functional components such as seed rotor mechanism, feed shaft , drive components etc. A 22 mm diameter bright bar at the lower portion of front beam and a 25X 2 mm square pipe support beam, 16 cm above the front beam were fixed using weld brackets to the rectangular frame. The double disc furrow opener assembly unit front point fitted to the bright bar using 'U' shape bracket tensioned with compression spring, the top point to the support square beam using a 10 x 6mm size flat supported by compression spring. Due to such an arrangement each furrow opener has independent movement as for field undulations to maintain uniform depth in placement of seeds. Flexible plastic tubes were arranged to seed catch spouts to deliver the same to furrow openers. The planter was also tested under field conditions at 2 and 3.5km/h forward speeds for sowing of maize with the optimized variables.

RESULTS AND DISCUSSION

Graded seeds of maize and castor were used for this study. The mean physical dimensions, length, width and thickness of maize and castor seeds were 8.50, 8.15 and 4.10 mm and 11.38, 7.83 and 5.56 mm, respectively. The thousand seed weight of maize and castor seeds obtained were 183.5g and 255.7g, respectively.

Effect of operating speed on seed metered :

The theoretically designed and actual mean number of seeds metered from the metering mechanisms (manually count) at different forward speeds for selected variety of maize (DHM-117) and castor crop (Jyothi) varied from 184.8 to 192.6, 185.8 to 187.6, respectively. The theoretical number of seeds to be dropped from the seed plate in one cycle (30 rotations of feed shaft) are 180, however, slight variations was observed in the actual number of seeds collected and counted by manual labour (Fig.1).The cell fill ratio ranged from 102.67 to 107 per cent and 103.22 to 104.22 per cent for maize and castor, respectively but the variation was not significant (Table 1).When seed types are considered, the difference in the per cent of cell fill for the two crops may be due to the differences in the shape and size of the seed. No seed breakage was observed in case of maize, but in few trials less than one per cent castor seed breakage was observed. The results reported by Chauhan *et al.* (1999) on planter test rig using sunflower seed with inclined plate metering mechanism revealed that,

Table 1 : Performance of seed metering mechanisms at different speeds

Forward speed, km/h	Mean cell fill,%	Broken seed,%	Multiples index,%	Miss index,%	Quality of feed index %	Precision %
Maize						
2.5	102.67	Nil	0	9.50	90.50	14.71
3.5	101.44	Nil	0	2.32	97.68	24.34
5.0	104.66	Nil	0	14.63	85.37	27.53
Castor						
2.5	102.67	0.63	0	5.55	94.45	23.70
3.5	107.00	0.82	0	2.77	97.22	23.75
5.0	104.66	0.69	2.27	15.00	82.73	30.45

the cell fill varied from 182 to 163 per cent, indicating multiple seed pickups by the seed rotor plate when planter forward speed ranged from 2 – 5km/h. The present seed metering mechanism under investigation was capable of metering almost single seed per cell and also variation in seed metered minimal as the speed of operation increased from 2.5 to 5 km/h, which was highly desirable feature for a planter.

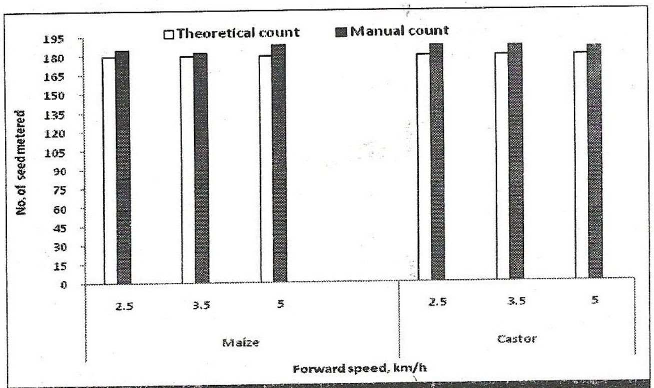

Fig. 1: Performance of horizontal plate in seed metering

Effect of travel speed on seed spacing :

The mean spacing and seed spacing distribution data obtained from the grease belt tests for the planter configuration at three speeds is summarized in Fig.2 and 3.The mean seed spacing observed at different speeds ranged from 19.3 to 23.14 cm and 19.9 to 22.67cm, respectively for maize and castor (Fig.2). The mean seed spacing alone may not explain true picture of the planter performance, so, the data obtained were analyzed for qualitative parameters based on the theoretical spacing between the seeds, x_{ref} (20cm).The first frequency distribution was based on intervals of 0.5x_{ref} and second distribution was based on intervals of 1.5 x_{ref} (Table 1).The three frequencies represented the quality of feed index, multiple index and miss index, as referred in ISO 7256-1 standard (International Standardization Organization,1984). The results more clearly represented in the frequency distribution with intervals equal to 1.0 x_{ref}. Single seed or quality of feed index varied for maize and castor between 90.5 to 97.7 per cent and 94.45 to 97.22 per cent, respectively when forward speed varied from 2.5 to 3.5km/h. The speed of operation did not affect the multiple indexes in both the seeds. However, it influenced miss index due to which the quality of feed index decreased drastically at higher speed ie 5km/h. The calculated precision (14.7 – 30.4%) indicates a steady increase in variability about the drop point at higher speeds for maize as presented in Table 1. Singh and Mane (2011) studies on a cup type seed metering mechanism with okra seeds using grease belt test stand show that, though the quality of feed index for cup feed mechanism is 100 per cent, the precision was very low (3.4 - 6.3%) in the speed range of 1 to 2.75 km/h.

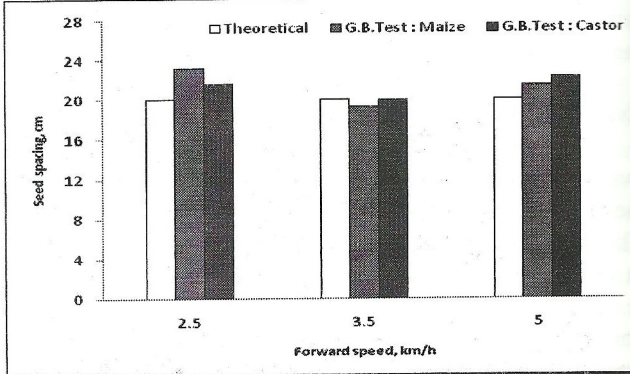

Fig. 2: Comparison of mean seed spacing

The spacing frequency occurrences results (Fig. 3) show that, the planter forward speed has pronounced effect on both types of seeds metered by the horizontal rotor plate. This was indicated by the deviation of distribution of frequency of occurrences each other. However, no definite trend in relationship between the speed and spacing frequency was observed. In all the distributions, the frequency was always higher for middle spacing ranges and decreased as the spacing interval decreased / increased. This also clearly indicated that the horizontal rotor recorded lower range of multiple seed pickups, which ultimately aided in achieving the over all mean seed spacing very closer to the designed theoretical spacing 20 cm of the seed rotor. The peak percentile frequency obtained for maize and castor ranged 34 to 60 per cent and 33 to 66 per cent, respectively in grease belt tests in spacing interval of 15 to 25cm and the peak percentile frequency was always higher at 2.5 km/h speed. Dhalin *et al.* (2004) results with cup type rotor plate using seed planter test rig pointed that, the mechanism not able to give higher frequency percentile for maize and groundnut when the set theoretical spacing is 7.5cm. The laboratory trials on the designed horizontal rotor plate seed metering mechanism hence proved the capability of metering the selected two crop seeds more effectively even at higher speeds, at which many of the existing planters were not able to give satisfactory performance.

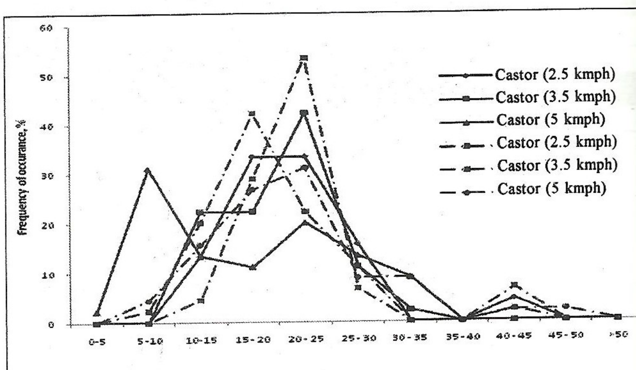

Fig. 3: Distribution of spacing on grease belt

The proto-type of the developed horizontal rotor plate metering mechanism planter is shown in Fig.4 and field performance results of the planter are presented in Fig.5. At an average speed of 2 and 3.5km/h, most of the seeds (70 and 65%) were sown in a spacing interval of 15 – 30 cm, which also indicates the higher quality of feed index for the developed planter. Among these, highest per cent 27.5 and 24 per cent of seed planted at the required spacing of 20 – 25cm at 2 and 3.5km/h speeds, respectively. Considerable variations in seed distribution frequencies were observed between grease belt and fields tests. This was expected because of ground wheel penetration variations while in operation due to uneven pre-sowing field preparation and seed bouncing effects.

Fig. 4: Proto-type horizontal plate planter

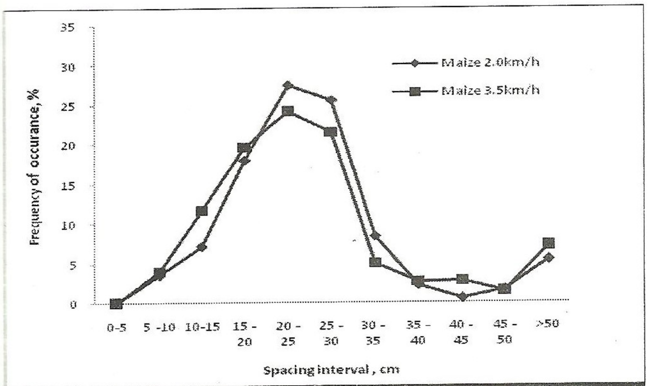

Fig. 5: Distribution of spacing under field conditions

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