COMPARATIVE STUDY ON LABORATORY AND FIELD PERFORMANCE OF ELECTRONIC PLANTER FOR LARGE SEEDS

ABSTRACT

In Precision planting the placement of single seed in the soil at the desired plants spacing is very important. With this objective a seven-row electronic planter for large seeds like ground nut, soyabean and maize was developed using inclined plate type seed metering mechanism. The metering unit was synchronized with the forward speed of tractor with the help of micro controller-based circuit. The developed metering unit was tested in the laboratory using opto-electronic sensor and on field for Ground nut, maize and soyabean at the forward speeds of 2.5, 3 and 3.5 km/h. The seed to seed spacing, seed rate and seed breakage was calculated for laboratory and field and the results were statistically analyzed and compared. The field and laboratory readings show more deviations in ground nut as compared to maize and soyabean. The optimum condition for operation was found to be 3.5 km/h for ground nut and maize seeds and 3.0km/h for soyabean.

Keywords: Precision Planting, inclined plate metering mechanism, opto- electronic sensor, grease belt method, seed uniformity, seed spacing, electronic planter.

INTRODUCTION

Precision agriculture is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for the purpose of improving crop performance and environmental quality. The largest part of production increase is attributed to the increased utilization of mechanical and electrical energy by developing more effective machines and implements.Among the machines contributing to higher yield in current farming are planting machines. The precision planting of crops is progressing in the country, however there is no indigenous precision planting machines available in the country. Some imported substitutes are available but being too costly are beyond the reach of common farmers. For crop production, seeds are normally required to be sown in the well prepared seed bed, maintaining row to row and plant to plant spacing. Various types of planters and seed drills have been developed but the problem still persists, like the missing of seeds, over filling, etc.(Maleki*et al.* 2006).A possible method to develop a variable-rate seeder is to add a controller to a conventional drill which can change the speed of the seed meter drive shaft on-the-go (Jafari *et al.* 2010). The seed-metering system is an important component in row-crop planters in terms of uniform seed distribution (Navid *et al.* 2011).Inclined plate seed metering device consists of a metering plate with cells on its periphery to carry one seed in each cell at appropriate time from hopper to the furrow through a seed tube.As the power source drives the planter in field, metering plate rotates and pick up the seed in its cell against the pull of gravity (Anantachara*et al*. 2010). Previously various effort has been done to implement precision in the work by introducing electronics and sensors (Aware, *et al*., 2008) in the metering unit of planters, by introducing LED systems for metering systems but the problems like slippage and skidding of ground wheel still persists. So keeping these points in view a project was undertaken to develop an electronic planterwith inclined plate metering unit. The performance evaluation of planter was conducted in laboratory using the combination of opto- electronic sensor system and grease belt system. The field performance was also evaluated and compared with the laboratory outcomes.

LITERATURE REVIEW

A plenty of work has been going on in various parts of the world for incorporating electronics in precision planting mechanism. As the electronic mechanisms are more efficient than their mechanical counterparts, efforts are being made to develop a precision planter which can effectively work in field condition as per the crop requirements. Aware *et al.*(2008) developed electronic metering mechanism for 3 rows planter powered by18 hp garden tractor. It consisted of hoppers, frame, ground wheel and power transmission system as main components. Electronic metering mechanism consisted of proximity distance sensor, ground wheel plate, 12V DC battery, 12V, 42 rpm DC motor, cell plate etc. as major components. Groove size on the cell plate was designed using spatial dimensions of cowpea seed.Shinde *et al*. (2009) undertook research to develop an electronic metering mechanism for Jyoti Multi crop planter and to test the prototype for sowing groundnut. Electronic seed metering contained distance sensing unit, check valve activating system with microprocessor, software programme, and solenoid switches.Sahoo and Shrivastava (2003) developed and evaluated the performance of a prototype planter to plant soaked okra seeds. The machine had a modular hopper and an inclined type metering unit.

Kocher*et al*. (1998) used the opto-electronic seed spacing evaluation system that measured time intervals between seeds and detected front-to- back location of seed drop events relative to the planter to rapidly determine planter seed spacing uniformity in the laboratory.Seed spacing obtained with the opto-electronic system were compared with measurements of the same seed spacing obtained from the grease belt test stand.Lan *et al*. (1999) studied the opto-electronic sensor system for measuring seed spacing uniformity with different types of seeds.The tests were conducted with different types of seeds including regular-pelleted (diameter, 3.8–4.5 mm), mini-pelleted (diameter, 3.2–4.0 mm), and medium- encrusted sugar beet seeds (3.2-3.6 mm in diameter by 1.8–2.6 mm in thickness), and pelleted chicory seeds (diameter, 2.8–3.3 mm). Results showed that the adjusted opto-electronic seed spacing were not significantly different from the same seed spacing measured with the grease belt test stand.Karayel et al., (2006) studied the seed uniformity and distribution in planters. The performance of the high-speed camera system in terms of seed spacing evaluation was compared with a sticky belt test stand, used as a reference. Identical seed patterns were evaluated applying both methods simultaneously using wheat and soybean seeds. Anantachar*et al.*(2010) established the relationship between the factors and the performance parameters viz., seed rate, seed spacing and percent seed damage using regression analysis.The results showed that the ANN model predicted the performance parameters of the seed metering device better than the statistical models.However, the results needed to be verified by conducting planting operation under actual field conditions.Panning *et al*. (2000) evaluated five planter configurations for seed spacing uniformity at three field speeds using a seed location method in the field and a laboratory method involving an opto-electronic sensor system. Planter seed spacing uniformity was described using the coefficient of Precision (CP3) measure. Results showed that CP3 measures determined using the laboratory test method were significantly different from those determined using the field test method. This indicated that the laboratory test method may be useful to screen out planters or planter units with a poor uniformity of seed metering.Singh *et al*. (2005) investigated the performance of the seed-metering device of a pneumatic planter under laboratory and field conditions to optimize the design and operating parameters for cottonseed planting. The effect of operational speed of the disc, vacuum pressure and shape of the entry of seed hole were evaluated by examining the mean seed spacing, precision in spacing (coefficient of variation), miss index, multiple index, and highest quality of feed index. With the help of available literature, the seed to seed spacing, number of cells of metering plate, speed of operation, circuit design and testing parameters for laboratory and field were selected. Literature review helped in drafting the methodology of the experiment.

MATERIALS AND METHODS

Fabrication of electronic metering mechanism

An electronic metering unit was assembled on inclined plate seed metering mechanism (Koley2012).The hopper was fabricated by using a MS sheet of 3 mm thickness. A 460 mm × 20 mm MS sheetwas bent at an angle of 85° to form the base. Another two MS sheet, triangular in shape of base 300 mm and height 230 mm were welded from sides to form the complete hopper. A circular hole of 180 mm was cut to set the metering plates. The number of cells on metering plates were calculated by selecting the optimum speed of rotation of metering plate as 60 rpm, as above that the seeds gain enough of kinetic energy, problems of higher cell fill and breakage of seeds occur. The dimensions of the cells were as follows, Length- 15 mm, Breadth- 6 mm, Thickness- 6 mm, No of cells-8. The metering plates were rotated by DC motors, which were driven by an electronic circuit. The power source for the motors was tractor battery.The speed of metering plate was synchronized with the speed of travel by using a micro-controller. For a particular seed, for instance ground nut, the change in speed of operation would change the rpm of motor. By this method seeds could be efficiently metered and planted with ease. The complete flow chart of working of the electronic unit is shown in Fig. 1 below.

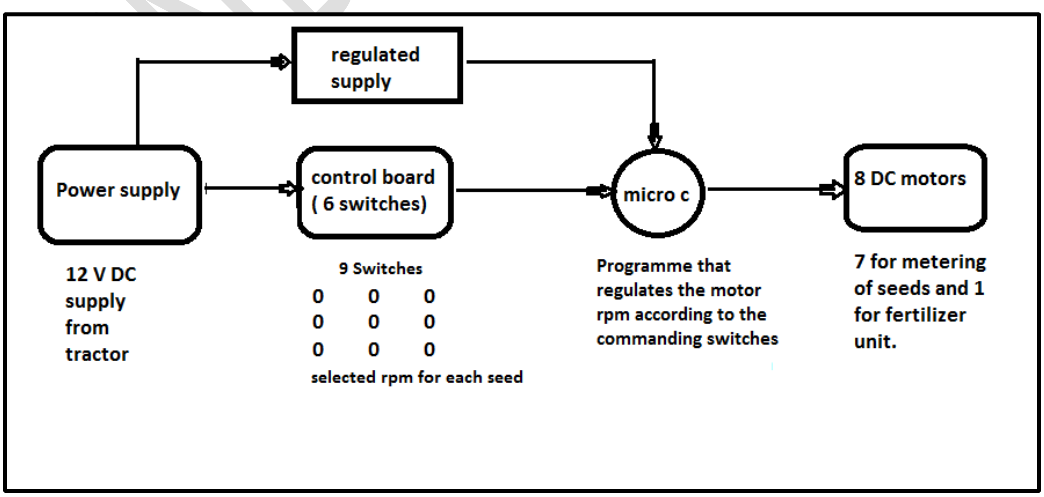

Fig. 1: Flow chart of the electronic seed metering mechanism

Laboratory Testing

The electronic metering unit was mounted over a grease belt 3555 mm long and the tests were carried out. The opto- electronic sensor was fitted in the seed tube just above it touches to the grease belt. The rollers were driven by a 1hp variable speed DC motor whose speed was varied to control the forward speed. The greased belt was driven at three speed levels of 2km/h, 2.5km/h and 3 km/h. The seed to seed spacing, seed rate and seed breakage were measured using grease belt as well as opto- electronic sensor system.

Fig. 2: Grease belt setup with opto- electronic sensor mounted on metering unit for laboratory testing.

Development of Prototype

The prototype was developed for a seven rows by assembling seven hoppers on a frame. The length of the frame was 2160mm in order to set the furrow openers at a row to row distance of 300mm recommended for ground nut planting. The width of the frame was limited to 380mm to set each hopper. Seven hoppers were placed at an interval of 150mm each, so that every seed directly comes out in the seed tube. The height of the frame was maintained at 310 mm from the ground level. The base frame of the hopper was 2100mm long, 270mm width and at a height of 75 mm from the main frame. Two pedestals were placed at the ends of the frame to give motion to the hopper unit for angle settings according to angle of repose requirements for various seeds. Shoe type furrow openers were used for further penetration. The tines are made of mild steel flat having width 45 to 65 mm and thickness 12 to 15 mm. Boot and tube are of mild steel sheet with minimum 1.60 mm thickness. Shoes are made of carbon steel with a minimum thickness of 4.0 mm. The inclined plate metering units were placed over each furrow opener to form the complete unit. The images of the complete unit are shown in Fig.3.

Fig. 3: Complete prototype unit of the seven rows electronic planter

Field Testing

The evaluation of planter was done in field and important field parameters like field efficiency, draft, fuel consumption etc. were noted. The same variables are used for laboratory and field trials (IS 6813:2000). The results of laboratory and field were compared. The experimental parameters are presented in Table1.

Table 1: Variables for testing of electronic metering mechanism

S.No.	Parameters	No of levels	Level Values

	Independent Variables		
1	Seed type	3	Ground nut(a1), maize(a2) and soyabean(a3)
2	Speed of operation (km/h)	3	2.5(b1), 3.0(b2) and 3.5(b3) km/h
	Dependent Variables		
1	Seed to seed spacing (cm)		
2	Seed Rate (kg/ha)		
3	Seed breakage (per cent)		

RESULTS AND DISCUSSION

Laboratory and field experiments were carried out to analyze the variation in seed spacing, seed rate and seed breakage of ground nut, maize and soyabean seeds with respect to the forward speed of operation. In laboratory, the statistical results showed that, with an increase forward speed (speed of metering plate) the seed to seed spacing decreased, but the results were insignificant. It was examined that with an increase in speed of seed metering plate seed rate increased (Table 2-4). This is clearly because seed rate and seed spacing are inversely proportional to each other. The readings obtained from opto-electronic sensor system closely resembles to that of grease belt results. The R^2 values of the results of opto-electronic sensor system lay around 0.98 whereas for grease belt it was around 0.97. The opto-electronic sensor unit was more efficient in sensing the seed count. This eliminates the deviations due to rolling, interaction with surface of belt in grease belt.

The study has derived outcomes in terms of laboratory experiments and field trials (Table 2-7). The main purpose of the experiments was to study the disparity between the results obtained in field and laboratory (Table 8). The maximum variation of 11.31 per cent in seed spacing was found for ground nut seed at the speed of 2.5 km/h. This shows the effect of field conditions on seed movement in the hopper. The vibrations created by the travel of tractor in field increase the movement of seeds in hopper and this decreases the cell fill efficiency of the metering plate. The effect is also found due to the variation in speed of travel for such a slow speed, as the circuit is programmed for the particular speed of 2.5 km/h at that time. The minimum variation is also found for ground nut seed of 0.1 per cent at the travel speed of 3.5 km/h, hence it can be said that, 3.5 km/h is more suitable for sowing of ground nut seeds. The variation of seed spacing has not much affected the seed rate of the seeds, the maximum variation of 2.2 per cent at the travel speed of 3.5 km/h, which was acceptable.

For maize seed, the maximum variation of 5.25 per cent in seed spacing was found at the speed of 2.5 km/h. This shows the effect of field conditions on the seed uptake by the metering plate. The uneven shape of maize influences more in field due to the movement of seeds in hopper. The minimum variation for maize seed was observed as 0.3 per cent at the travel speed of 3.5 km/h, hence it can be said that, 3.5 km/h is more suitable for sowing of ground nut seeds. The variation of seed spacing has not much affected the seed rate of the seeds, the maximum variation of 2.5 per cent at the travel speed of 2.5 km/h, which was acceptable. The minimum variation in seed rate is 1.19 per cent at the speed of 3.5 km/h, this proves the fact that 3.5 km/h is more suitable for the sowing operation of maize by the planter.

For soyabean seed, the variation in seed spacing was found in the range of 3.6 to 3.8 per cent for different speed of operation. This shows that the effect of field conditions is equally affective on all the speed of operations. The variation in terms of seed rate shows that the maximum difference of 2.92 per cent is found at the speed of 3.5 km/h and the minimum of 1.04 per cent at the speed of 3.0 km/h. In contrast with the results obtained for the maize and ground nut, the optimum speed of operation suitable for sowing of soyabean seeds is 3.0 km/h.

All the results found in relation with the seed spacing and seed rate of the seeds on field shows that, the sowing operation is more consistent and suitable at higher speed i.e. 3.5 km/h.

Table 2: Effect of travel speed on seed spacing, seed rate and seed breakage of ground nut in laboratory

Interaction	Spacing (cm)	Seed rate (kg/ha)	Breakage (per cent)
a1b1	15.67	83.40	1.3
a1b2	13.53	87.47	1.45
a1b3	11.80	90.33	1.70
CD (1per cent)	NS	6.105	NS
SE(mean)	0.5856	1.499	0.1504

Table 3: Effect of travel speed on seed spacing, seed rate and seed breakage of maize in laboratory

Interaction	Spacing (cm)	Seed rate (kg/ha)	Breakage (per cent)
a2b1	27.03	21.37	1.0
a2b2	25.50	25.40	1.4
a2b3	22.57	28.87	1.62
CD(1 per cent)	NS	6.105	NS
SE(mean)	0.5856	1.499	0.1504

Table 4: Effect of travel speed on seed spacing, seed rate and seed breakage of soyabean in laboratory

Interaction	Spacing (cm)	Seed rate (kg/ha)	Breakage (per cent)
a3b1	9.27	78.83	0.48
a3b2	8.43	94.47	1.03
a3b3	6.90	107.63	1.29
CD(1per cent)	NS	6.105	NS
SE(mean)	0.5856	1.499	0.1504

Table 5: Effect of travel speed on seed spacing and seed rate of ground nut in field

Interaction	Spacing (cm)	Seed rate (kg/ha)
a1b1	17.67	81.70
a1b2	14.13	86.67
a1b3	11.80	92.37
CD (5 per cent)	NS	3.084
SE(mean)	0.5033	1.038

Table 6:Effect of travel speed on seed spacing and seed rate of maize in field

Interaction	Spacing (cm)	Seed rate (kg/ha)
a2b1	28.53	20.93
a2b2	26.10	24.80
a2b3	21.87	29.53
CD (5 per cent)	NS	3.084
SE(mean)	0.5033	1.038

Table 7: Effect of travel speed on seed spacing and seed rate of soyabean in field

Interaction	Spacing (cm)	Seed rate (kg/ha)
a3b1	9.63	75.87
a3b2	8.77	94.47
a3b3	6.0	110.87
CD (5 per cent)	NS	3.084
SE(mean)	0.5033	1.038

Table 8: Comparison between laboratory and field outcomes in terms of seed spacing and seed rate for ground nut, maize and soyabean

	Interaction	**lab Spacing**	**Field spacing**	**Variation (%)**	**lab Seed rate**	**Field seed rate**	**Variation (%)**
Ground nut	a1b1	15.67	17.67	11.31	83.10	84.70	1.8
	a1b2	13.53	14.13	4.2	87.47	87.67	0.09
	a1b3	11.80	11.9	0.1	90.33	92.37	2.2
Maize	a2b1	27.03	28.53	5.25	21.37	21.93	2.5
	a2b2	25.50	26.10	2.2	25.40	25.80	1.5
	a2b3	22.57	21.87	0.3	28.87	28.53	1.19
Soyabean	a3b1	9.27	9.63	3.7	78.83	79.87	1.30
	a3b2	8.43	8.77	3.8	94.47	95.47	1.04
	a3b3	6.65	6.90	3.6	107.63	110.87	2.92

CONCLUSIONS

The seven-row electronic planter with inclined plate metering mechanism can serve the planting purpose efficiently and conveniently. The R^2 values of seed spacing for opto-electronic sensor system was higher than that of grease belt test, hence we can say that opto-electronic sensor system is more reliable system for the testing and evaluation of the metering mechanisms in laboratory.The seed spacing decreased with respect to increase in speed of travel for both laboratory and field, but it was found statistically insignificant. Significant increase in seed rate was found with respect to travel speed in both field and laboratory. The seed breakage increases insignificantly with respect to travel speed in laboratory. Ground nut seed showed the maximum variation in seed spacing and seed rate between laboratory and filed data, but the variation is negligible at 3.5 km/h speed of travel. Hence it is suitable for ground nut sowing. For maize seed, 3.5 km/h speed was found most suitable for field operations.In contrast with ground nut and maize, soyabean seeds can be suitably sown at 3.0 km/h of speed, this might be the effect of shape and metering plate of the seeds. The programming of micro-controller can be modified for continuous forward speed of travel, as the exact speed of tractor is difficult to maintain on field. Vigorous experimentation is required to make a successfully functional electronic planter on field.

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