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Comparative Performance Evaluation of Metering Devices of Planters

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A B S T R A C T

The comparative performance of inclined plate planter, raised bed planter & pneumatic planter was evaluated at half and full hopper fill using 2.5km/h & 3km/h speed alternatively for evaluation effects on miss index (MI), multiple index (MPI), feed index (QFI), cell fill percentage (CF) & standard deviation (SD) with the agronomical properties of seeds, design, and fabrication of experimental setup and development of seed uniformity calculator. For generation of database seed uniformity of planter, an experimental setup of planter is designed and fabricated at the College of Agricultural Engineering, Jabalpur. The laboratory and workshop facilities of the Institute were used for development and fabrication of the machine.

Introductions

The present study deals with the agronomical properties of seeds, design, and fabrication of experimental setup and development of seed uniformity calculator. For generation of database seed uniformity of planter, an experimental setup of planter is designed and fabricated at the College of Agricultural Engineering, Jabalpur. The laboratory and workshop facilities of the Institute were used for development and fabrication of the machine.

Materials and Methods

Theoretical seeding rate (R_{st})

The number of seed planted per hectare was calculated by using the following relationship (Bakhtiari and Loghavi, 2009):

$$R_{st} = \frac{10^8}{W \times x_s}$$

Where,
R_{st} = Theoretical seeding rate, seed/ha;
W = Row width, cm; and
x_s = Seed spacing along the row, cm.

Seeding mass rate

The total mass of seed planted per hectare expressed in Mg ha^{-1} was calculated by using the following relationship (Bakhtiari and Loghavi, 2009):

$$R_{sm} = \left[\frac{M}{w \times x_s}\right] \times 100$$

Where,
R_{sm} = Seeding mass rate, Mg/ha;
M = Average mass of one seed, g;
W = Row width, cm; and
x_s = Seed spacing along the row, cm.

Speed calculation

Planter speed is very important for testing. Controllable speeds are necessary for most of the operations performed with a tractor. They help give the farmer a larger degree of control in certain situations, such as field work. Planter speed was evaluated by timing and measuring the distance from the middle of the back tire.

$$\text{Actual planter speed (km/h)} = \frac{\text{Distance traveled(m)}}{\text{Time taken (sec)}} \times \frac{3600}{1000}$$

John Deere 5310 Diesel (9 speed) nominal forward travel speeds

Speed gear position	Gear	Speed (mph)	Speed (km/h)
A	1st Gear	1.32	2.13
	2nd Gear	1.91	3.07
	3rd Gear	2.60	4.19
B	1st Gear	3.12	5.02
	2nd Gear	4.50	7.24
	3rd Gear	6.14	9.88
C	1st Gear	8.56	13.78
	2nd Gear	12.36	19.89
	3rd Gear	16.86	27.13

Source: Nebraska tractor tests report. Paper 2063, 1998.

Field preparation

To select the field for testing near the energy laboratory in the college of agriculture engineering JNKVV Jabalpur M.P.
Parches 20 m^3 fine sand from the Suhagi Jabalpur M.P.
Make a 15X5X0.25 pit.
Fill all send in prepared appropriate size of pit.
Leveled bed with the help of manual leveler.
Field preparation is completed for testing.

Specifications: 1) Inclined Plate Planter

Height (mm)	**1010**
Distance between furrow openers	300 mm
No.of ground wheel	1
No. of lugs on ground wheel	12
Types of lugs	Flat pinte
Number of rows in planter attachment	6 (Maximum)
Seed metering mechanism	Inclined plate with cell type
Fertilizer metering	Fluted roller
Furrow openers	Inverted T type

Specifications: Multi crop raised bed planter

Power source (hp)	**35 hp Tractor**
Length (mm)	2500
Width (mm)	1215
Height (mm)	1010
Distance between furrow openers	300 mm
No.of ground wheel	One
No. of lugs on ground wheel	12
Types of lugs	Flat Pointed
Number of rows in planter attachment	6 (Maximum)
Seed metering mechanism	Inclined plate with cell type
Fertilizer metering	Fluted roller
Furrow openers	Inverted T type

Pneumatic metering system

Pneumatic metering systems are used for accurate metering of single seed in precision planters. In this system an aspirator sucks air from a seed drum where a particular negative air pressure (vacuum) is maintained. Negative air pressure holds the seeds in pockets on a plate until the seeds are conveyed up to the bottom where the suction pressure is cut-off and the seed are dropped into the seed tubes due to gravity.

Seed discs with different hole sizes are used for different kinds of seeds. Seed velocity at the delivery end is low, therefore, uniform seed distribution in the furrow is achieved.

Vacuum-type metering devices have 99 to 100% cell fill efficiency and 99 to 100% single seed picking efficiency if clean and graded seed are used.

Details of seed plates used on the pneumatic planter

Seeds	Recommended seed spacing, mm	No.of holes on plate	Seed-hole diameter, mm	Air suction pressure,kPa
Soybean	50	16	4	3.5
Sorghum	100	16	2	3.0
Pigeon pea	100	16	2	3.5
Mustard	150	16	1.5	2.0
Okra	200	4	2	2.0
Maize	300	6	4.5	4.5
Groundnut	150	6	4.5	5.3
Cotton	450	6	2.5	2.0

Source: RNAM, 1991

Results and Discussion

Effect of speed on performance of Half-filled Hopper

Inclined plate plant

With increase in operating speed from 2.5 to 3 km/h, miss index (MI) and quality of feed index (QFI) were increased from 17.19% to 20.46 % and from 57.1% to 58.08% respectively but multiple index (MPI) and cell fill percentage (CF) were decreased from 25.71% to 21.47% and 101.61% to 99.73% respectively The reason may be that, the seed metering plates were getting less time to pick the seeds at 3 km/h speed compared to 2.5 km/h. Standard deviation (SD) also increased from 5.96 to 6.05 due to increase in spacing. Staggenborg*et al.,* (2004), reported that as planter speed increases, efficiency of the seed metering process reduced.

Multi crop raised bed planter

With increase in operating speed from 2.5 to 3 km/h, miss index (MI) increased from 17.74% to 17.89%, multiple index (MPI) decreased from 19.02% to 15.65%. The metering disc did not get enough time to pick up seeds, resulting in higher miss index (MI) and low multiple index (MPI) at higher speed, (Singh *et al*., 2005) also found the same trend. Quality of feed index (QFI) increased from 63.24% to 66.46%, cell fill (CF) decreased from 95.18% to 94.94% and standard deviation (SD) increased from 5.13 to 5.74.

Pneumatic planter

With increase in operating speed from 2.5 to 3 km/h, miss index (MI) increased from 15.48% to 15.51 %, multiple index (MPI) decreased from 4.1% to 3.93%, quality of feed index (QFI) increased from 80.42% to 80.56%, cell fill (CF) decreased from 99.87% to 99.57%, standard deviation (SD) increased from 4.48 to 4.78. Singh *et al.,* (2005) reported that miss index (MI) increases with increases in speed with lower vacuum pressure. At higher speeds, the metering disc did not get enough time to pick up seeds, resulting in higher miss index. The multiple index (MPI) on the other hand was low at higher speed but increase as the pressure was increased.

Effect of speed at Full-filled hopper

Inclined plate planter

With increase in operating speed from 2.5 to 3 km/h, miss index (MI) increased from 7.79% to 8%, multiple index (MPI) decreased from 44.28% to 39.07%.Singh *et al.,* (2005) also reported similar findings. The quality of feed index (QFI) increased from 47.94% to 52.93%, cell fill percentage (CF) decreased from 130.85% to 129.2%. The reason may be

that, the seed metering plates were getting less time to pick the seeds at 3 km/h speed compared to 2.5 km/h, standard deviation (SD) increased from 4.53 to 5.11.Staggenborg*et al*., (2004), found that increasing planter speed resulted in greater seed spacing and standard deviations (SD).

Multi crop raised bed planter

With increase in operating speed from 2.5 to 3 km/h, miss index (MI) increased from 13% to 14.35 %, multiple index (MPI) decreased from 32.23% to 24.89%, quality of feed index (QFI) increased from 54.78% to 60.76%, cell fill percentage (CF) decreased from 100% to 99.37% The reason may be that, the seed metering plates were getting less time to pick up the seeds at 3 km/h speed compared to 2.5 km/h. Standard deviation (SD) increased from 5.68 to 5.76.

Pneumatic planter

With increase in operating speed from 2.5 to 3 km/h, miss index (MI), multiple index (MPI) and cell fill (CF) decreased from 15.26% to 15.13%, 6.73% to 3.93% and 99.21% to 96.56% and quality of feed index (QFI) increased from 78.01% to 80.56%, respectively. The reason may be that, the seed metering plates were getting less time to pick the seeds at 3 km/h speed compared to 2.5 km/h. Standard deviation (SD) increased from 4.53 to 4.92.

Effect of hopper fill on performance of planters at 2.5 km/h

Inclined plate planter

With increase in hopper fill from half to full, miss index (MI) decreased from 17.19% to 7.79%, multiple index increased (MPI) from 25.71% to 44.28%, quality of feed index (QFI) decreased from 57.1% to 47.94%, cell fill percentage (CF) increased from 101.61% to 130.85% .The reason may be that, the shape of metering cell allowed two or more seeds at a time. Standard deviation (SD) decreased from 5.96 to 4.53.

Multi crop raised bed planter

With increase in hopper fill from half to full, miss index (MI) decreased from 17.74% to 13 %, multiple index (MPI) increased from 19.02% to 32.23%, quality of feed index (QFI) decreased from 63.24% to 54.78%, cell fill (CF) increased from 95.18% to 100%. The reason may be that, the shape of metering cell/seed hole was not allowing two or more seeds at a time. Standard deviation (SD) decreased from 5.68 to 5.13.

Pneumatic planter

With increase in hopper fill from half to full, miss index (MI) decreased from 15.48% to 15.26%, multiple index (MPI) increased from 4.1% to 6.73%, quality of feed index (QFI) decreased from 80.42% to 78.01% and cell fill (CF) decreased from 99.87% to 99.21% The reason may be that, the pneumatic planter metering device based on suction pressure thus the multiple index (MPI) was less compared to the inclined plate planter and multi crop planter. Standard deviation (SD) increased from 4.48 to 4.53.

Effect of Hopper Fill on performance of planters at 2.5 km/h

Inclined plate planter

With increase in hopper fill from half to full, miss index (MI) decreased from 20.46% to 8 %, multiple index (MPI) increased from 21.47% to 39.07%, quality of feed index (QFI) decreased from 58.08% to 52.93%, cell fill (CF) increased from 99.73% to 129.2% The reason may be that, the shape of metering cell was allowing two or more seeds at a time. Standard deviation (SD) decreased from 6.05

to 5.11.

Multi crop raised bed planter

With increase in hopper fill from half to full, miss index (MI) decreased from 17.89% to 14.35 %, multiple index (MPI) increased from 15.65% to 24.89%, quality of feed index (QFI) decreased from 66.46% to 60.76%, cell fill (CF) increased from 94.94% to 99.37% The reason may be that, the shape of metering cell/seed hole was not allowing two or more seeds at a time. Standard deviation (SD) decreased from 5.76 to 5.74.

Pneumatic planter: With increase in hopper fill from half to full, miss index (MI) decreased from 15.51% to 15.13%, multiple index (MPI) increased from 3.93 % to 4.4 %, quality of feed index (QFI) decreased from 80.56% to 80.47%, cell fill (CF) decreased from 99.57 % to 96.56 % The reason may be that, the pneumatic planter metering device based was on suction pressure, thus the multiple index (MPI) was very less compared to the inclined plate planter and multi crop planter. Standard deviation (SD) increased from 4.78 to 4.92.

Table.1

Comparative results of the field experiments of planters at forward speed 2.5 km/h with hopper fill- half

Particulars	Inclined Plate Planter			Mean	Raised Bed Planter			Mean	Pneumatic Planter			Mean
Furrow	1	2	3		1	2	3		1	2	3	
No. of Distances	35.67	38.33	36	**36.67**	35.33	35.3	40	**36.88**	26.3	26	29.67	**27.32**
Average (Distances)	8.52	7.87	7.64	**8.01**	7.95	8.4	7.59	**7.98**	10	10.52	9.69	**10.07**
Standard Deviation	6.49	6.04	5.55	**6.03**	5.55	6.53	5.73	**5.94**	4.72	5.54	6.13	**5.46**
No. of Misses	5	5	4	**4.67**	5.67	5.6	6	**5.76**	1.33	2.67	4	**2.67**
No. of Accumulation	5.33	6.67	5.33	**5.78**	6	4.6	8.3	**6.30**	2.33	3	5.67	**3.67**
Coefficient of Variance	0.76	0.77	0.73	**0.75**	0.7	0.778	0.75	**0.74**	0.47	0.53	0.63	**0.54**
Planting Errors	1.75	1.84	1.57	**1.72**	2.17	1.92	2.53	**2.21**	0.94	1.48	2.21	**1.54**
Cell fill %	100.69	102.07	102.07	**101.61**	98.33	92.78	94.44	**95.18**	99.2	96	109.6	**101.60**

Comparative results of the field experiments of planters at forward speed 3 km/h with hopper fill -half												
Particulars	Inclined Plate Planter			Mean	Raised Bed Planter			Mean	Pneumatic Planter			Mean
Furrow	1	2	3		1	2	3		1	2	3	
No. of Distances	33	33.67	32.67	**33.11**	39.7	38.3	41.3	**39.77**	32.67	31.3	28.6	**30.86**
Average (Distances)	8.61	8.59	9.27	**8.82**	7.8	8.14	8.13	**8.02**	9.56	10.22	10.57	**10.12**
Standard Deviation	5.13	6.53	6.49	**6.05**	5.09	6.801	5.39	**5.76**	5.44	5.35	5.39	**5.39**
No. of Misses	3.67	5.67	5.33	**4.89**	4.33	7.3	6.33	**5.99**	4	2	3	**3.00**
No. of Accumulation	2.33	5	3.33	**3.55**	3	7	2.33	**4.11**	3	3.33	3.67	**3.33**
Coefficient of Variance	0.6	0.76	0.7	**0.69**	0.65	0.84	0.66	**0.72**	0.57	0.53	0.509	**0.54**
Planting Errors	1.1	1.91	1.6	**1.54**	1.21	2.45	1.38	**1.68**	1.45	1.15	1.58	**1.39**
Cell fill %	100.83	98.35	100	**99.73**	93.04	93.67	98.1	**94.94**	99.33	98.67	100	**99.33**

Comparative results of the field experiments of planters at forward speed 2.5 km/h with hopper fill- full												
Particulars	Inclined Plate Planter			Mean	Raised Bed Planter			Mean	Pneumatic Planter			Mean
Furrow	1	2	3		1	2	3		1	2	3	
No. of Distances	60.6	62.67	57	**60.09**	42.66	44	41.67	**42.78**	31	28.67	29.67	**29.78**
Average (Distances)	4.973	5.18	5.59	**5.25**	7.183	6.79	7.36	**7.11**	10.19	10.56	10.12	**10.29**
Standard Deviation	4.357	4.78	4.45	**4.53**	4.781	5.32	5.28	**5.13**	4.35	4.69	4.54	**4.53**
No. of Misses	2.66	3.33	3	**3.00**	2.33	4.33	4.67	**3.78**	1.67	2	1.33	**1.67**
No. of Accumulation	18.66	24	15.67	**19.44**	10.66	9	8	**9.22**	2	1.33	1	**1.44**
Coefficient of Variance	0.876	0.92	0.8	**0.87**	0.674	0.78	0.72	**0.72**	0.42	0.44	0.45	**0.44**
Planting Errors	2.63	2.63	1.98	**2.41**	1.99	1.99	1.99	**1.99**	0.8	0.79	0.53	**0.71**
Cell fill %	132.23	130.58	129.75	**130.85**	99.37	100	100.63	**100.00**	100	98.67	98	**98.89**

Comparative results of the field experiments of planters at forward speed 3 km/h with hopper fill- full												
Particulars	Inclined Plate Planter			Mean	Raised Bed Planter			Mean	Pneumatic Planter			Mean
Furrow	1	2	3		1	2	3		1	2	3	
No. of Distances	53	55	55	**54.33**	32.33	33.67	40	**35.33**	28.67	25.67	28.67	**27.67**
Average (Distances)	5.76	5.35	5.79	**5.63**	7.76	9.12	7.61	**8.16**	10.3	11.17	10.04	**10.50**
Standard Deviation	5.27	5	5.06	**5.11**	5.08	6.79	5.36	**5.74**	4.93	4.94	4.89	**4.92**
No. of Misses	3.3	3	3	**3.10**	3.33	7	5	**5.11**	2.67	2.67	2	**2.45**
No. of Accumulation	16.3	15.33	14	**15.21**	2.67	4	8.67	**5.11**	1	1.67	1.33	**1.33**
Coefficient of Variance	0.91	0.96	0.87	**0.91**	0.66	0.74	0.72	**0.71**	0.48	0.44	0.49	**0.47**
Planting Errors	2.24	2.01	1.87	**2.04**	1.22	2.14	2.24	**1.87**	0.87	1.14	0.79	**0.93**
Cell fill %	132.23	131.4	123.97	**129.20**	99.37	101.27	97.47	**99.37**	100.67	100	98.67	**99.78**

Conclusion of the study are as follows:

This chapter deals with the summary of the study, its conclusive remarks and identified suggestion for future works.

1. The moisture content of seeds was measured and found the moisture content of soybean 9.10 % standard deviation was 0.152 and coefficient of variance was 0.018.
2. The bulk density of soybean seeds was 0.718 g/cm^3 standard deviation was 0.006.
3. The 1000 grain weight of soybean was measured and found the sample weight is 127.8 g.
4. Germination percentage of soybean seed varieties of JS 97-52 was 90.4% and after testing germination percentage was 89.6%.
5. Seed damaged percentage under laboratory testing was found 0.8 %. However, mechanical damage to seeds due to metering device was negligible.
6. Soybean seed planted per hectare was 6, 66,667 seeds and theoretical seed rate was 80 kg/ha.
7. Misses was higher for raised bed planter (5.99) and inclined plate planter (4.89) than pneumatic planter (3.00) and accumulation was higher in case of raised bed planter (4.11) while inclined plate planter (3.55) then pneumatic planter (3.33) at condition of half hopper filling with speed 3 km/h.
8. Vacuum type metering devices in pneumatic planter have 99 to 100% cell fill efficiency and 99 to 100 % single seed picking efficiency is eliminated in pneumatic system. There is no effect of hopper filling.

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