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National Academy of Agricultural Science (NAAS) Rating : 3.03

Field Performance Evaluation of a Multi-crop Seed Drill for Line Sowing of Groundnut

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ABSTRACT: *A low cost and manually operated multi crop seed drill with suitable dimensions of cup in cup feed metering mechanism for a particular crop has been developed and evaluated in the field condition to study its seed pattern characteristics and economic viability for small and marginal farmers in the state of Odisha. The seed drill developed was evaluated with the prevailing groundnut variety 'AK 12-24' in the Central farm OUAT, Bhubaneswar in the year 2008 with the objectives of optimizing the dimensions of cup for groundnut sowing, studying the seed pattern characteristics like seed rate deviation, seed distribution and seed damage, performance evaluation and finally its economics of use. From the experiments it was found that the dimension of the cup i.e. 12 mm × 7.36 mm was found to be best and was used successfully up to a peripheral speed of 18.84 m/min with the desired seed rate deviation, seed distribution and seed damage for sowing of groundnut. The actual field capacity of the seed drill was 0.048 ha / h with a field efficiency of 75.00 per cent and there was a net savings of Rs. 664 per hectare for groundnut in comparison to the local traditional practice. This seed drill costing of Rs. 1850 and total operating cost of Rs. 13.85 per hour may solve the problem of line sowing of seeds particularly for the small and marginal farmers of Odisha to enhance production and productivity as a whole.*

Key words: *Groundnut sowing, Farm Mechanization, Seed drill, Cup feed metering mechanism,*

The seed metering mechanism is the most vital component of the seed drill. The performance of a seed drill is mainly dependent on the type of metering device. In addition to this, the type of soil and field condition, preparation of seed bed, speed of operation and power source also affect the performance of the seed drill (Kepner *et al.*, 2000). The crop yield as well is affected by plant population, row spacing, plant to plant spacing, type and variety of seed and their emergence (Ojha and Micheal, 1978).

The fluted roller feed type metering device is very popular in India. This type of metering device is very much suitable for grain crops and not for bold seeds. Moreover there is a concern for this type of metering device when the seed damage exceeds three per cent (Goel and Verma, 2000). Another metering device used was of cell feed type for manually operated seed drill. In this type of metering device, controlling of the seed rate was difficult. It was reported that the slightest displacement of brush contact varied the seed rate to a great extent under the field condition. In recent past, cups having semi circular type have been introduced for seed metering device in manufacturing of seed drill (Sahoo and Srivastava, 2000). Due to vibration and shock, the seed retention and release for these cups were poor. So the cups were modified to cylindrical at top and conical at the bottom for better retention of seeds.

The socio-economic conditions of the farmers in the state Odisha (Anonymous 2005) do not permit them to have different seed drills for different crops. They are therefore bound to follow the traditional practice and face difficulty in intercultural operations and overall management of their crop. As the yield rate is low, farmers derive marginal benefit out of these crops. However the seed drills having cup feed metering mechanism can be suitably utilized for various crops only by changing the cups and with minor modifications (Garg and Dixit, 2003). Hence, the seed drill having cup type metering mechanism

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can be suitably used as a multi crop seeder for the crops like paddy, groundnut, green gram and black gram. So, studies on cup feed metering mechanism will help in developing a multi crop seeder for its versality in line sowing of various crops and enhancing the production and productivity.

Considering the above aspects, the present study was undertaken with the following objectives for sowing of groundnut seeds.

1. To optimize the dimensions of the cup for sowing of groundnut seeds
2. To optimize the peripheral speed of cup disc for the above mentioned crop
3. To evaluate the cup-feed metering device for seed-pattern considering seed rate deviation, seed distribution and seed damage for sowing of groundnut
4. To develop a seed drill using optimized cups
5. To evaluate the above seed drill
6. To study its economics

The spatial dimensions of the seed of the promising variety were measured. The dimensions of cup and peripheral speed of cup disc were optimized using the developed test rig (Goswami 2001) to achieve the desired seed pattern. A seed drill was then fabricated, evaluated (Anonymous, 1993) and its economics was studied for its feasibility for the small and marginal farmers in the state of Odisha.

THEORETICAL CONSIDERATION

The suitable size of cup for the promising variety of groundnut i.e. AK 12-24 has been standardized using a test rig. This variety was selected as it is generally grown in Odisha having yield potential of 1200 kg / ha. In order to develop and evaluate a multi crop seeder the standardized cups are used as cup feed metering mechanism and the cups are made replaceable. The details of theoretical aspects for the study are presented below;

Thousand Grain Weight

Thousand grain weight can be calculated taking approximately 500 grains from the sample at random. Subsequently thousand grain weight can be calculated using the following formula.

The weight of 1000 grains on 'as is' basis = $\frac{a \times 1000}{b} gm$; where a = weight of the whole grains, gm; b = number of whole grains in the sample weighed

Bulk Density

Bulk density of seed is defined as the total weight of the seeds per unit total volume.

$$\text{B.D.} = \frac{W}{V}$$; where B.D. = Bulk density, gm/ cm^3; W = Weight of seed sample, gm and V = volume of seed sample, cm^3

Seed Rate Deviation

The seed rate deviation was calculated using the following formula.

$$\text{Seed rate deviation, \%} = \frac{\text{Theoretical amount of seeds to fall in 5m length} - \text{(-) Actual amount of seeds collected in 5m length}}{\text{Theoretical amount of seeds to fall in 5m length}} \times 100$$

The seed rate deviation was taken positive in all cases.

Seed Distribution

The seed distribution was calculated using the following formula.

$$\text{Se} = \left(1 - \frac{\text{Y}}{d}\right) \times 100$$; where, Se = Seed distribution, %; Y = average numerical deviation of number of seeds per meter length of row from average number seeds per metre run; d = average number of seeds per metre length of row

Seed Damage

The seed damage was calculated taking nearly one kg of sample and using the following formula.

$$\text{Seed damage, \%} = \frac{\text{Weight of the damaged seeds from the sample}}{\text{Weight of the sample}} \times 100$$

The seeds before metering were tested to ensure their invisible damage and the seeds after passing through metering were tested for visible damage. There after the internal damage of seeds were found out from the germination test.

MATERIALS AND METHODS

The spatial dimension of groundnut variety, AK-12-24, was studied and accordingly the cup dimensions were fixed. The peripheral speed of cup disc was varied from 6.28 m/min to 23.56 m/min. The experiment was conducted using the test rig developed in the laboratory. The experiment was designed on 2 factors C.R.D. The independent factors were cup dimension and peripheral velocity of cup disc. The dependent parameters were seed distribution efficiency, seed rate deviation and seed damage.

A manually operated seed drill was developed having cup feed-metering device as per the results obtained from the test rig. Subsequently the seed drill was evaluated under the field condition.

Details of Test Rig of Testing

The test rig developed to evaluate the cup feed metering device was consisting of two major sections. In the section one, the hopper, pickup chamber funnel in feed shaft with cup discs and 65 watts power source suitable belt and pulley for power drive and variac were there. A stroke counter was used to measure the revolutions of feed shaft. In the section two, 1492 watts power source with speed reduction unit, suitable belt and pulley for power drive, endless canvas belt 10.8 m length and 80cm width, frame rollers and idler were there.

A thin layer of grease was applied to the belt so as to facilitate the proper embedding of seeds without any displacement. The belt used was demarcated for four rows and one side was marked in centimeters for easy reading. A stroke counter was used to measure the revolutions of driving shaft. The test rig was used to get the peripheral speed of cup disc from 6.28 m/min to 23.56 m/min with a belt speed from 0.97 km/hr to 2.4 km/hr to get the desired spacing. The results obtained on groundnut variety AK-12-24 are presented in the following Table 1. Five different sizes of cups i.e. 10.60 mm, 8.76 mm, 7.36 mm, 6.27 mm and 5.41 mm depths with diameters of 10mm, 11mm, 12mm, 13mm and 14mm respectively were prepared keeping the volume constant and were used for the study. The five different peripheral speeds of the cup discs i.e. 6.28 m/min, 9.42 m/min, 12.55 m/min, 18.84 m/min and 23.56 m/min were chosen. The belt speed was calculated and maintained to study the seed rate deviation, seed distribution and seed damage.

Manually Operated Seed Drill

A manually operated seed drill was developed using ten numbers of cups on the cup disc for groundnut variety, AK-12-24. The main components of seed drill were 1. hopper 2. pickup chamber 3. feed shaft 4. cup discs 5. furrow opener 6. funnels 7. ground wheels and 8. handle. The cup feed type seed drill has been shown in Fig. 1. The technical specifications of the seed drill developed have been presented in Table 2. The manually operated seed drill was fabricated as per the prescribed test codes (Anonymous, 1993).

Table 1
Evaluation of Cup Feed Metering Mechanism of Groundnut Variety AK-12-24

Cup Dimensions	*Peripheral speed of cup disc (m/min)*	*Seed rate deviations (%)*				*Seed distribution (%)*				*Breakage of seeds (%)*			
		R_1	R_2	R_3	*Mean*	R_1	R_2	R_3	*Mean*	R_1	R_2	R_3	*Mean*
10mm diameter	6.28	4.80	4.76	4.52	4.69	79.66	79.52	79.82	79.65	0.78	0.48	0.51	0.59
and 10.60mm	9.42	4.92	4.81	4.64	4.79	79.38	79.38	79.56	79.44	0.42	0.86	0.86	0.71
depth	12.55	4.89	4.96	4.81	4.89	79.12	79.13	79.31	79.13	0.51	0.86	0.87	0.74
	18.84	5.00	5.01	4.96	4.99	78.91	78.96	79.10	78.99	0.71	0.81	0.86	0.79
	23.56	5.12	5.10	5.09	5.10	78.64	78.68	78.91	78.74	0.84	0.91	0.98	0.91
11mm diameter	6.28	4.84	4.82	4.61	4.76	80.88	80.72	80.96	80.85	0.48	0.69	0.53	0.56
and 8.76mm	9.42	4.96	4.94	4.72	4.87	80.59	80.48	80.68	80.53	0.89	0.58	0.59	0.68
depth	12.55	5.02	5.01	4.84	4.96	80.31	80.20	80.51	80.40	0.61	0.71	0.83	0.78
	18.84	5.12	5.10	4.96	5.06	80.11	80.01	80.30	80.14	0.68	0.82	0.94	0.88
	23.56	5.16	5.18	5.06	5.13	79.92	79.88	80.12	79.97	0.90	0.97	0.96	0.94
12mm diameter	6.28	2.21	2.46	2.51	2.39	81.36	81.14	81.21	81.23	0.56	0.51	0.54	0.53
and 7.36mm depth	9.42	2.35	2.50	2.62	2.49	81.02	80.82	80.96	80.93	0.62	0.61	0.64	0.62
	12.55	2.44	2.63	2.76	2.61	80.78	80.54	80.63	80.78	0.68	0.69	0.65	0.67
	18.84	2.60	2.72	2.88	2.73	80.46	80.26	80.35	80.35	0.75	0.84	0.81	0.78
	23.56	2.76	2.90	2.96	2.87	80.14	80.01	80.12	80.09	0.86	0.92	0.94	0.90
13mm diameter	6.28	4.89	4.91	4.74	4.85	80.63	80.48	80.52	80.54	0.58	0.53	0.55	0.55
and 6.27mm depth	9.42	4.96	4.99	4.86	4.94	80.35	80.16	80.21	80.24	0.64	0.53	0.86	0.67
	12.55	5.06	5.09	4.98	5.04	80.10	79.83	79.94	79.95	0.81	0.63	0.82	0.75
	18.84	5.18	5.20	5.10	5.16	79.86	79.56	79.61	79.67	0.93	0.78	0.82	0.84
	23.56	5.29	5.36	5.22	5.29	79.52	79.30	79.34	79.33	1.01	0.81	0.91	0.91
14mm diameter	6.28	4.96	4.98	4.92	4.95	79.90	79.84	79.68	79.83	0.62	0.58	0.61	0.60
and 5.41mm depth	9.42	5.08	5.09	5.02	5.06	79.63	79.51	79.39	79.51	0.68	0.69	0.81	0.72
	12.55	5.19	5.21	5.16	5.19	79.31	79.20	79.16	79.23	0.91	0.74	0.84	0.83
	18.84	5.26	5.38	5.30	5.31	79.02	78.96	78.91	78.95	1.02	0.89	0.92	0.99
	23.56	5.39	5.51	5.46	5.45	78.81	78.68	78.71	78.73	1.10	0.98	0.99	1.02

Table 2
Technical Specifications of Manually Operated Seed Drill having Cup-feed-metering Mechanism

1.	Name	:	Manually operated seed-drill
2.	Make	:	College of Agricultural Engineering and Technology, O.U.A.T., Bhubaneswar.
3.	Overall dimensions		
	i) Length	:	630 mm
	ii) Width	:	600 mm
	iii) Height	:	410 mm
	iv) Weight	:	12 kg (Empty Weight)
4.	Ground drive details		
	i) No. of wheels	:	Two
	ii) Type of Wheels	:	Lugged wheel
	iii) Effective dia	:	320 mm
	iv) Lug height	:	40 mm
5.	Seed metering	:	Cup feed type
6.	Hopper capacity	:	Volume 0.0187 m^3
7.	Row spacing	:	Groundnut 20 cm
8.	No. of rows	:	2
9.	Suitability for crop	:	Paddy, groundnut, black gram and green gram
10.	No. of person engaged	:	One
11.	Seed covering mechanism	:	Scraper type
12.	Special feature	:	Cups are easily replaceable
13.	Cost	:	Rs. 1850.00
14.	Cost of operation per hour	:	Rs. 13.85

Table 3
Physico-chemical Properties of Soil Sample Collected from the Experimental Field

A.	**Mechanical composition**		
	i) Particle size distribution		
	(a) Sand	:	81.24%
	(b) Silt	:	7.80%
	(c) Clay	:	10.96%
	ii) Textural class	:	Sandy loam
B.	**Physical properties**		
	i) Bulk density (g/cm^3)	:	1.54
	ii) Particle density (g/cm^3)	:	2.63
	iii) Moisture content (by weight)		
	(a) Water holding capacity	:	23.69%
	(b) Field capacity	:	17%
	(c) Permanent wilting point	:	7%
C.	**Chemical properties**		
	i) Organic matter (%)	:	0.935
	ii) Organic carbon (%)	:	0.56
	iii) Available N (kg/ha)	:	295
	iv) Available P_2O_5 (kg/ha)	:	20
	v) Available K_2O (kg/ha)	:	150
	vi) Ph	:	5.1
	vii) EC	:	0.04 mhos/cm.

Figure 1: Field evaluation of manually operated seed drill

Evaluation of Seed Drill

The seed drill was evaluated in the Central Farm, O.U.A.T., Bhubaneswar, Odisha in the year 2008. In order to evaluate the seed drill for groundnut, three plots were taken having 12.5 m. x 8 m. size each. The physico chemical properties of soil sample colleted from the experimental field have been shown in Table 3. The crop was replicated thrice in three fields and the mean of the observations were taken. The seed bed was prepared by twice rotatilling the soil. The over all performance (Table 4) was evaluated for the groundnut as per the prescribed test codes and economics (Table 5) of the use of the seed drill were also calculated for its feasibility for the small and marginal farmers. The seed pattern characteristics were observed after germination of seeds under field conditions.

RESULTS AND DISCUSSION

The results of the different experiments conducted during the course of the studies are presented in this section. The experimental data collected from the test rig and field conditions were analyzed and discussed in the following sub-heads.

- Studies on seed rate deviation, seed distribution and seed damage of groundnut variety AK-12-24
- Field performance of the developed seed drill.
- Economics of seed drill.

The seed rate deviation varied from 2.39 to 5.45 per cent. The results indicated that the minimum seed rate deviation occurred with cup No.3 having 12mm diameter with a peripheral speed of 6.28 m/min. This may be due to improper filling of cup when the cup diameter was less than 12mm and when the cup diameter was more than 12mm seed retention was difficult because of the slippage. It was also found that the seed rate deviation was increasing with the increasing of peripheral speed. This may be due to improper filling at higher speed and scattering of seeds during centrifugal discharge due to the increase in kinetic energy of seeds.

The seed distribution efficiency varied from 78.73 to 81.23 per cent. It was found that the maximum seed distribution efficiency was found with cup No.3 with a peripheral speed of 6.28 m/min. It was also found that the seed distribution efficiency was decreasing in increasing the peripheral speed. This may be due to scattering of seeds during centrifugal discharge as the seeds posses more kinetic energy.

The seed damage was varied from 0.53 to 1.02 per cent. It was found that the minimum seed damage was attributed with cup No.3 with a peripheral speed of 6.28 m/min. The seed damage was found increasing with increase in peripheral speed. This may be due to higher impact of the seeds. From the analysis of results it was found that the dimensions of cup of

12 mm × 7.36 mm was found best with a permissible peripheral speed up to 18.84 m/min with an overall efficiency of 77.54 per cent. But the seed pattern observed was precision drilling up to peripheral speed 12.55 m/min and at 18.84 m/min the seed pattern was of drilling the seeds.

Field Performance of Manually Operated Seed Drill

The manually operated seed drill was calibrated in the laboratory and the seed rate was fixed at 125kg per hectare. The field performance of the manually operated seed drill was observed in the Central Farm O.U.A.T., Bhubaneswar and the mean results have been presented in Table 4. During the field test, mean actual seed rate was found to be 122.75 kg/ha. The lower seed rate obtained was due to skidding of ground wheel while operating in the field. Average depth of placement of seeds was found to be 5.20 cm. The average seed distribution efficiency was found to be 79.67. The effective field capacity of the seed drill was 0.048 ha/hr with field efficiency of 75.00 per cent and the over all performance of the manually operated seed drill was found satisfactory for groundnut.

Table 4
Field Performance of Manually Operated Seed Drill

Sl. No.	*Particulars*	*Observed values*
1	Crop	Groundnut
2	Variety	AK-12-24
3	Date of sowing	24.06.2008
4	Type of soil	Sandy loam
5	Size of plot	12.5m × 8m
6	Soil moisture, % (db)	20.65
7	Mean weight diameter of clods, mm	0.36
8	Average speed, km/hr	1.60
9	Coverage width, m	0.40
10	Depth of seed placement, cm	5.20
11	Actual seed rate observed, kg/ha	122.75
12	Deviation form laboratory rate setting, %	1.83
13	Draft, kg	16.5
14	Effective field capacity, ha/hr	0.048
15	Field efficiency, (%)	75.0
16	Field machine index, (%)	80.84
17	Seed distribution efficiency, (%)	79.67
18	Average number of plants /hill	1.02
19.	Seed pattern observed	Precision drilling

Economics of Manually Operated Seed Drill

The cost of manually operated seed drill is Rs. 1850.00 with an operating cost of Rs.13.85 per hour. The comparative cost of sowing for manually operated seed drill has been presented in Table 5. In case of groundnut, the local practice followed is planting behind the indigenous plough. The labour hour requirement and bullock hour requirement per hectare in case of planting behind the indigenous plough were found to be 57.14 and 19.04 respectively with a cost of Rs. 952.00 per hectare. But the cost of planting with manually operated seed drill was only Rs. 288.00 with a net saving of Rs. 664.00 per hectare compared to the above traditional method.

CONCLUSIONS

A manually operated seed drill was developed having cup-feed metering device. The appropriate cups were used for the crop like groundnut. The seed drill was evaluated under the field condition to evaluate its performance, seed pattern and economics. The following research findings were drawn as per the research work conducted.

1. The groundnut variety AK 12-24 was evaluated and from the analysis of results, the dimensions of the cup i.e. 12 mm x 7.36 mm was found to be best and was used successfully up to a peripheral speed of 18.84 m / min considering seed rate deviation, seed distribution and seed damage. The seed pattern observed was of precision drilling up to 12.55 m / min and at 18.84 m/min, it was of drilling the seeds.
2. The actual field capacity of the manually operated seed drill was 0.048 ha / h with a field efficiency of 75.00 per cent for groundnut variety AK-12-24.
3. There was a net savings of Rs. 664.00 per hectare by using the seed drill for groundnut in comparison to the local method followed.

Table 5
Comparative Cost of Sowing for Manually Operated Seed Drill with Local Method

Crop	*Methods*	*Labour requirement (man-h/ha)*	*Bullock-h requirement/ ha*	*Cost of operation of the m/c (Rs./ha)*	*Total cost of sowing (Rs. /ha)*	*Net savings (Rs. /ha)*
Groundnut	Planting behind indigenous plough	57.14	19.04	-	952.00	664
	Manually operated seed drill	20.83	-	288.00	288.00	

The research findings are expected to help developing a multicrop seed drill economically using the cup feed metering device for the sowing of other major crops like paddy, greengram, blackgram etc. The results also revealed to have desired seed pattern under the field conditions. As a result of this, the study is expected to promote line sowing for the benefit of the farmers.

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