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RESEARCH ARTICLE

Design modifications of cup in cup feed metering seed drill for seed pattern characteristics study of black gram seeds

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ABSTRACT : Proper design of cup in cup feed metering seed drill is very much important to enhance the performance of a seed drill. Earlier the cups used were of semi circular type. 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. An experimental test rig was developed in the laboratory in the Department of Farm Machinery and Power, OUAT, Bhubaneswar to evaluate the best suitable dimensions of cup for the black gram variety PU-30. Five different sizes of cups of 7.41mm, 4.74mm, 3.29mm, 2.42mm and 1.85mm depths with diameters of 4mm, 5mm, 6mm, 7mm and 8mm, respectively were prepared keeping the volume constant and were used for the study. The five different peripheral speeds of the cup discs were chosen to 6.28 m/min, 9.42 m/min, 12.55 m/min, 18.84 m/min and 23.56 m/min. The belt speed was calculated and maintained to study the seed rate deviation, seed distribution and seed damage. It was found that the dimensions of cup *i.e.* 6 mm x 2.89 mm was found to be best and was used successfully up to a peripheral speed of 18.84 m/min and an overall efficiency of 79.94 per cent. The above dimensions of the cup may be taken to develop a suitable seed drill for use in the field condition for sowing of black gram seeds.

KEY WORDS : Farm mechanization, Seed drill, Cup feed metering mechanism, Black gram sowing

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INTRODUCTION

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 Michale, 1978).

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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 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 black gram seeds.

To optimize the dimensions of the cup for sowing of black gram seeds, to optimize the peripheral speed of cup disc for the above mentioned seed and to evaluate the cup-feed metering device for seed-pattern characteristics considering seed rate deviation, seed distribution and seed damage for sowing of black gram

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.

Theoretical consideration :

The suitable size of cup for the promising variety of black gram *i.e.* PU-30 has been standardized using a test rig. This variety was selected as it is generally grown under upland conditions in Odisha having yield potential of 580 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 $= \frac{a \times 1000}{b}$ g ; where a = weight of the whole grains, g; 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.

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

Seed rate deviation :

The seed rate deviation was calculated using the following formula.

$$\text{Seed rate deviation, \%} = \frac{\begin{array}{l}\text{Theoretical amount of seeds}\\ \text{to fall in 5m length}\\ (-)\text{Actualamount of seeds}\\ \text{collected in 5m length}\end{array}}{\begin{array}{l}\text{Theoretical amount of seeds}\\ \text{to fall in5m length}\end{array}} \text{x100}$$

The seed rate deviation was taken positive in all cases.

Seed distribution :

The seed distribution was calculated using the following formula.

$\text{Se} = \left(1 - \frac{Y}{d}\right) \times 100$; 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.

EXPERIMENTAL PROCEDURE

The spatial dimension of black gram variety, PU-30, was studied (Table A) and accordingly the cup dimensions were fixed (Table B). 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 (Fig.A) developed in the laboratory. The experimental test rig having hopper and cup feed seed metering mechanism was evaluated in the sticky belt. The design considerations for the sticky belt method are shown below.

Table A : Physical properties and overall dimensions of selected seeds

Seed variety	1000 grains weight (g)	Moisture content (%) (w.b)	Bulk density (g/cc)	Average length (L) (mm)	Average breadth (B) (mm)	Average thickness (T) (mm)	Average size (S) (mm) $S = (LBT)^{1/3}$	Sphericity = $\left(\frac{S}{L}\right)$	Spacing (cm)	Seed rate (kg/ha)
Black gram PU-30	31.350	10.312	0.670	4.800	3.500	3.300	3.813	0.794	25 × 5	25

Table B : Calculation of dimensions of cup for selected seed

Variety	Cup diameter (mm)	Cylindrical height (mm)	Cone height (mm)	Total height (mm)
Black gram: PU-30	4	2.96	4.45	7.41
	5	1.89	2.85	4.74
	6	1.31	1.98	3.29
	7	0.97	1.45	2.42
	8	0.74	1.11	1.85

– A 2 HP electric motor with speed reduction unit was used for the drive mechanism.
– The uniform speed of the canvass belt was maintained at 1 to 2.5 km/h with suitable belt pulley arrangement.
– The endless canvass belt was prepared having 10.5 m length so as to take observations from top 5 m length.
– The width of the belt should be at least 80 cm to evaluate four rows having spacing of 20 cm.
– The canvass belt was graduated at the side so as to take observations easily.
– A thin layer of grease was applied on the canvass belt so that the seeds would not be displaced after dropping.

Fig. A: Test rig for metering of seeds through sticky belt

Details of test rig of testing :

The test rig (Fig. B) developed to evaluate the cup feed metering device was consisting of two major sections. In the

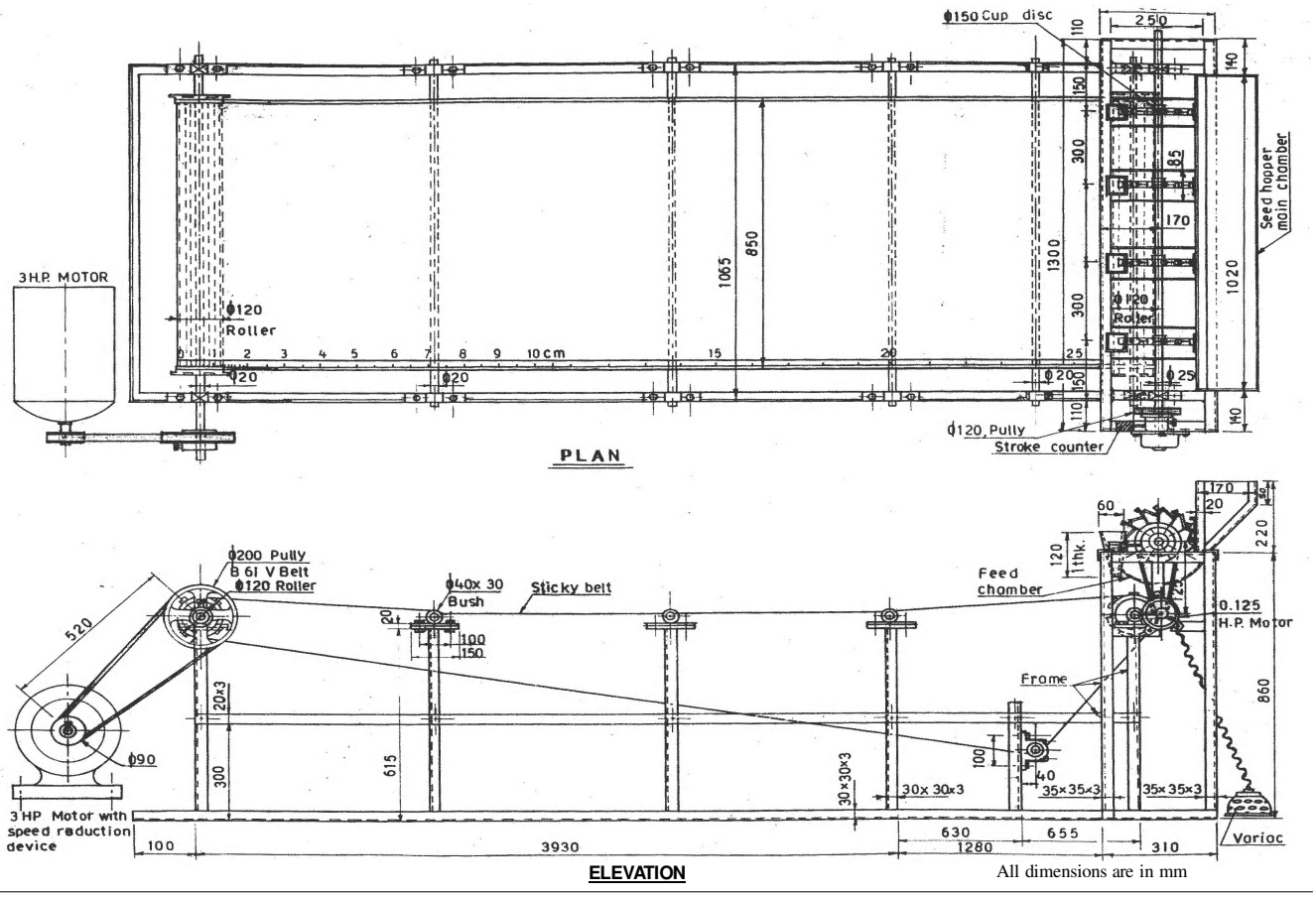

Fig. B : Test rig performance evaluation of cup feed metering device

section one, the hopper, pickup chamber funnel in feed shaft with cup discs and 65 watts power source with 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 as has been presented in Table C. Five different sizes of cups *i.e.* 7.41mm, 4.74 mm, 3.29 mm, 2.42 mm and 1.85 mm depths with diameters of 4mm, 5

Table C : Peripheral speed of cup disc and belt speed for maintaining desired spacing

Sr. No.	Diameter of cup disc (cm)	Rpm of cup disc	Peripheral speed of cup disc (m/min)	No. of cups in cup disc	Canvas Belt speed (km/hr)	Spacing to be maintained (cm)
1.	10	20	6.28	8	0.97	10
2.	10	30	9.42	8	1.44	10
3.	10	40	12.55	8	1.92	10
4.	10	20	6.28	10	1.21	10
5.	15	40	18.84	12	2.40	10
6.	15	50	23.56	12	3.6	10

Table D : Sample calculation for dimension of cup and hill spacing for black gram variety PU-30

A. Assumptions

Seed rate : 25 kg/ha

Spacing : 25 cm x 5 cm

B. Calculation for dimension of cup

No of hills per ha : $\frac{100000000}{25\times 5}=800000$

Amount of seeds to fall in each hill : $\frac{25000}{800000}=0.031g$

Thousand grain weight : 31.35 gm

No. of seeds in each hill : $\frac{0.031}{0.0313}=1$

Bulk density of seeds : 0.670

Volume of seeds in each hill : 0.0462 c.c.

Additional 20% volume : 0.00924

Total volume : 0.055

Cylinder volume, 1/3 of total volume : 0.0184

Height of cylinder taking diameter 8 mm : 0.73mm

Height of cone : 1.11 mm

Total height of cup : 1.84 mm

So for 8 mm diameter of cup, the cup height has been taken as 1.84 mm and with this cup dimensions 1 number of seed is to fall in each hill.

C. Calculations for hill spacing

Diameter of cup disc : 10 cm

Cup disc, rpm : 20

Peripheral speed of cup disc : 6.28 m/min

No. of cups in cup disc : 10

Belt speed : 0.61 km/hr

Hill spacing : $\frac{0.97\times 100000}{60\times 20\times 10}=5.10cm, \textit{or say } \mathbf{5}$

So with a belt speed of 0.61 km/hr hill spacing to be maintained is 5 cm

mm, 6 mm, 7 mm and 8 mm, 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.

Designs of ground wheel diameter, number of cups and cup disc diameter :

The ground wheel diameter of the seed drill was taken as 32 cm. The ground wheel of existing commercially available manually operated seed drill is only 25 cm. The larger diameter has been taken to rotate the ground wheel smoothly even if the seed bed is not prepared well. The ground wheel was prepared from 2.5 cm M.S. flat and eighteen nos. of pegs were provided on the periphery and the height of the pegs was 2.5 cm.

The number of cups can be calculated using the following formula:

$Z = \frac{\pi D}{X.S}$; where, Z= number of cups in the cup disc; D = ground wheel diameter; S =spacing in between the plants; N = seed metering shaft, r.p.m.; n = ground wheel, r.p.m.; X = gear ratio $\left(\frac{N}{n}\right)$; Assuming, D = 32 cm, X = 1 and S = 10 cm;

$$Z = \frac{\pi D}{XS} = \frac{3.142 \times 32}{1 \times 10} = 10.05 \approx 10$$

Therefore, the number of cups to be used in the cup disc is 10. In case of slow speed the seeds are discharged from the cup by gravity. Under this condition the guide plate is provided so that the seeds are directed to the seed funnel. In order to provide the guide plate the peripheral distance between two cups should be at least 3.25 cm. So the cup disc dia = $\frac{32.5}{\pi} = 10.34\,cm$.

Sample calculation for dimension of cup and hill spacing for black gram variety PU-30 has been mentioned in Table D.

EXPERIMENTAL FINDINGS AND ANALYSIS

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 are presented in Table 1.

Table 1 : Evaluation of cup feed metering mechanism of black gram variety PU-30

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
4mm diameter	6.28	3.82	3.64	3.38	3.61	80.78	80.92	80.84	80.85	0.46	0.47	0.60	0.51
and 7.41mm	9.42	3.95	3.72	3.46	3.71	80.46	80.64	80.52	80.54	0.44	0.88	0.54	0.62
depth	12.55	4.06	3.84	3.58	3.83	80.12	80.35	80.28	80.25	0.48	0.91	0.58	0.66
	18.84	4.12	3.92	3.71	3.92	79.89	80.12	80.03	80.01	0.52	0.90	0.72	0.71
	23.56	4.24	4.03	3.83	4.03	79.60	80.02	79.78	79.80	0.68	0.84	0.99	0.84
5mm diameter	6.28	3.61	3.52	3.22	3.45	81.36	81.54	81.41	81.44	0.38	0.46	0.58	0.47
and 4.74mm	9.42	3.72	3.64	3.31	3.56	81.02	81.28	81.11	81.14	0.42	0.52	0.65	0.53
depth	12.55	3.81	3.72	3.50	3.68	80.78	81.01	80.88	80.89	0.54	0.64	0.70	0.63
	18.84	3.92	3.84	3.63	3.80	80.46	80.78	80.59	80.61	0.62	0.72	0.80	0.71
	23.56	4.02	3.98	3.73	3.91	80.18	80.36	80.18	80.24	0.84	0.82	0.94	0.87
6mm diameter	6.28	1.68	1.82	1.92	1.81	82.36	82.48	82.52	82.45	0.22	0.28	0.61	0.37
and 3.29mm	9.42	1.79	1.93	2.01	1.91	82.12	82.19	82.28	82.20	0.31	0.32	0.63	0.42
depth	12.55	1.88	2.01	2.12	2.00	81.88	81.96	82.02	81.95	0.38	0.36	0.72	0.49
	18.84	1.97	2.12	2.20	2.10	81.59	81.68	81.88	81.72	0.42	0.48	0.76	0.55
	23.56	2.03	2.24	2.34	2.20	81.31	81.39	81.53	81.41	0.54	0.59	0.87	0.67
7mm diameter	6.28	3.58	3.47	3.42	3.49	81.86	81.79	81.82	81.82	0.39	0.48	0.59	0.49
and 2.42mm	9.42	3.67	3.58	3.63	3.63	81.58	81.46	81.54	81.53	0.44	0.54	0.66	0.55
depth	12.55	3.79	3.69	3.75	3.74	81.30	81.21	81.22	81.24	0.56	0.66	0.71	0.64
	18.84	3.94	3.85	3.91	3.90	81.06	80.96	81.01	81.01	0.64	0.74	0.81	0.73
	23.56	4.05	3.97	4.03	4.02	80.84	80.68	80.83	80.78	0.86	0.83	0.97	0.89
8mm diameter	6.28	3.67	3.52	3.56	3.58	81.16	81.24	81.38	81.26	0.48	0.46	0.63	0.52
and 1.85mm	9.42	3.74	3.65	3.70	3.70	80.88	80.96	81.06	80.97	0.48	0.90	0.56	0.65
depth	12.55	3.90	3.79	3.83	3.84	80.59	80.68	80.74	80.67	0.50	0.92	0.60	0.67
	18.84	4.02	3.93	3.95	3.97	80.31	80.39	80.42	80.37	0.54	0.94	0.78	0.75
	23.56	4.13	4.02	4.11	4.09	80.02	80.12	80.08	80.07	0.72	0.88	1.01	0.87

The seed rate deviation varied from 1.68 to 4.13 per cent. The results presented indicated that the minimum seed rate deviation occursred with cup No.3 having 6mm 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 6mm and when the cup diameter was more than 6mm 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 79.60 to 82.52 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 observed that the seed distribution efficiency was decreasing with 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 varied from 0.22 to 1.01 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 6 mm × 3.29 mm was found best with a permissible peripheral speed up to 18.84 /min with an overall efficiency of 79.56 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.

Conclusion :

The following research findings were drawn as per the data collected from the test rig.

The blackgram variety PU-30 was evaluated and from the analysis of results, the dimensions of the cup *i.e.* 6 mm x 3.29 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 peripheral speed of 12.55 m/ min. and at 18.84 m/min, it was of drilling the seeds. These research findings would help in developing a multicrop seed drill using the cup feed metering device for the sowing of other major crops like paddy, groundnut, green gram etc. to promote line sowing for the benefit of the farmers.

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