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Study of Different Operating Parameters on Seed Holding in the Single Seed Metering Unit

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Authors' contributions

This work was carried out in collaboration among all authors. Author BHB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. All the remaining authors managed the analyses of the study managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The present study was conducted to determine the "Effect of Different Operating Parameters on Seed Holding in the Single Seed Metering Unit".
Study Design: An attempt was made to development seed metering unit and evaluated for its performance with battery drive i.e. seed rate, seed holding ratio, single seed holding ratio, double seed holding ratio and missing index. The shapes of cells speed of seed plate and number of cells on seed plate were chosen as parameters. A factorial completely randomised design used for analysis of variance.
Results: At the end of the research, it was found that the cell's shape, peripheral velocity and number of cells on seed plate had an effect on the seed holding ratio (SHR) at a significant level of 5% ($P<0.05$). The diameter and thickness of the seed metering plates were 100 and 8 mm respectively. The hopper was of the trapezoidal section with height of 12.5 cm , volume 3510 cm^3 and thickness of material of 2.5 mm. For maize seed variety: Tulasi Naga If the velocity of seed plate increases then seed holding ratio decreases, seed holding ratio also decreased with increase in number of cells on seed plate. Oblong shape with extension was suitable for these seeds. For maize seed variety: Goodrej Ultra when the velocity of seed plate increased then seed holding ratio

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decreased, seed holding ratio also decreased with increase in number of cells on seed plate. Oblong shape was suitable for these seeds. For maize seed variety: Laxmi 2277 seed holding ratio increased with increase in velocity of seed plate, seed holding ratio also increased with increase in number of cells on seed plate. Oblong shape was suitable for these seeds.

Conclusion: The highest and least value of seed holding ratio is 94% at a speed of 30 rpm in shape 2(6 and 7 cells) and 31% at a speed of 30 rpm in shape 1(7 cells), 39% at a speed of 26 rpm in shape 2(6 cells) and 12% at a speed of 30 rpm in shape 1(7 cells), 45% at a speed of 26 rpm in shape 1(6 cells) and 6%at a speed of 30 rpm in shape 2(7 cells) for laxmi, goodrej and tulasi variety of seeds respectively.

Keywords: Seed planter; battery drive; seed holding ratio; single seed holding ratio; double seed holding ratio.

1. INTRODUCTION

Maize and cornmeal (ground dried maize) constitute a staple food in many regions of the world. Maize plays an important role in the fulfilment of the demand of human food. Maize is a major source of starch. Cornstarch (maize flour) is a major ingredient in home cooking and in many industrialized food products. Maize is also a major source of cooking oil (corn oil) and of maize gluten. The usage of maize for human consumption constitutes about 1/40th of the amount grown in the country.

In rain fed farming, numerous crops are grown and the success of crop production depends on timely seeding of these crops with reduced drudgery of farm labour. With the introduction of subsidy for various agricultural implements and non-availability of sufficient farm labour, various models of tractor drawn sowing implements becoming popular in dry land regions of Bangladesh. It is necessary for seeds to be placed at equal intervals within rows. In manual seeding with conventional practice, the higher and non-uniform plant population adversely affect grain yield of different crops [1]. The ultimate objective of seed planting using improved sowing equipment is to achieve precise seed distribution within the row. The achievement of the set seed spacing majorly depends on the machine’s technical variables such as the type of seed pickup mechanism, the machine operating speed, overall gear ratio between drive wheel and seed rotor, and to some extent on seed quality. Although, there are many planters having different seed metering mechanisms, the application of single seed metered plate mechanisms (horizontal, vertical and inclined plate) has increased rapidly due to better seeding performance than that of other mechanical rotors [2]

However, in recent times due to climate variability and lack of sufficient moisture in the soil for reasonably sufficient time in the sowing window period, farmers prefer to operate the planters at higher speeds to complete the sowing operation of various rain fed crops within a short period. Thus, the metering mechanism should be accurate enough to plant seeds at the required seed to seed distance in a row. This accuracy is expressed as the quality of the planter. Therefore, the proper design of a seed metering mechanism is essential for satisfactory performance of any seed planter.[3] The assessment of plant spacing and seed rate as provided by the planters is also crucial in analysing its performance. A variety of methods have been evolved to assess the performance of planter metering mechanism. Measuring the spacing between germinated plants after planting with machine is most common method. The accuracy of this method seriously affected by weather condition and more importantly by seed quality/viability. The second most prevalently used method is the grease belt test rig under laboratory conditions, which is unaffected by crop and soil conditions. No significant experiment has been done related to inclined plate seed metering device & flute type seed metering device for lacking of sufficient knowledge and technologies. Some studies are still going on. But no data have been published regarding the performance of inclined plate seed meter & flute type seed meter

Metering mechanism is the heart of sowing machine and its function is to distribute seeds uniformly at the desired application rates. The mechanism of a seed drill or fertilizer distributor which delivers seeds or fertilizers from the hopper at selected rates is called seed metering mechanism.

There are a number of seed metering devices available for use in a planter. The most common device is a rotating circular plate with cells which is provided at the bottom of seed hoppers. In some planters, vertical rotors, inclined rotors, canvas belts are also used the circular seed plates have notches or holes provided along the periphery called cells which pick up the seeds from seed hopper and drop them in to the seed tube. Depending upon the type of notches provided on the plates, the rotor is further classified in to Edge drop, Flat drop and Hill drop rotors. The cells carry the seeds in the cells of the rotor. The flat drop cell carries the seed on a platform of thickness half of the cell depth. Only one seed is allowed in the cell each time. In hill drop rotor, the cells are larger in size and admit many seeds at a time. The rotating plate receives the seeds from the hopper. The plate moves under an arrangement called cut-off which allows only those seeds which are accommodated in the cells.

2. MATERIALS AND METHODS

Seed metering plates were developed and fabricated. Laboratory experiments were conducted to study the performance evaluation of the seed plates for seeds of maize and to compare the operation with two rpm (26, 30) and two different shapes seed plates consisting 6 and 7 cells on seed roller. The details of materials used, experimental methodology and measurement techniques adopted during the course of investigation were described in this chapter.

2.1 Physical Properties of Seeds

2.1.1 Measurement length, width, thickness of maize seeds

Length, width and thickness of maize seeds are measured by digital vernier calliper with an accuracy of 0.01 mm.

2.1.2 Measurement of moisture content

Moisture content is measured by the portable digital moisture meter. The setting of p 5 should be kept for determining the moisture content of corn. The grain whose moisture content is to be determined is filled in the hopper and placed on the machine, then the push back button is pressed the whole grain fall into the machine. Within 2-5 sec the results will be displayed on the LCD display.

2.1.3 Measurement of true and bulk densities of maize seeds

The average bulk density of all the corn seeds was determined using the standard test weight procedure by filling a container of 500 ml with seed from a height if 150 mm at a constant rate and weighing the content.[4]

The average true density was determined using the toluene displacement method. The volume of toluene (C_7H_8) displaced was found by immersing a weighed quantity of dent corn seeds in the toluene.

2.1.4 Measurement of angle of repose

Angle of repose of the seeds was determined using a conical funnel. A box with a circular platform was placed in the funnel and the platform was kept horizontal with the help of three adjustable screws. The seed was poured in the box to its full depth. Then the seed gate was removed and the seed was allowed to flow from the funnel to form a standing heap of seed on circular platform. The height of the heap was measured. Then the angle of repose was calculated using the formula [5]

$$\theta = \tan^{-1} \frac{2 \times H_c}{D_c}$$

Where,

θ = angle of repose

H_c = height of cone formed, cm

D_c = diameter of platform on which cone was formed, cm

2.2 Seed Hopper

The seeds container as the name implies was a device in which the seeds to be planted are kept before their gradual release into the furrowed tunnel. The seed container also has a gate, with a handle on top to ease opening [6]

Volume of seed box is given by

$$V_b = 1.1\ V_s \quad (1)$$

Where, V_b =volume of seed box

V_s =volume of seed

Also

$$V_s = \frac{W_s}{\gamma_s}$$

Where, W_s = weight of seed in the box, g

γ_s = bulk density of seed, g/cm^3

Putting $V_s = \frac{W_s}{\gamma_s}$ in eqn. (1) We get

$$V_b = 1.1\frac{W_s}{\gamma_s}$$

2.3 Seed Metering Plates

Metering mechanism is the heart of machine and its function is to distribute seeds uniformly at the desired application rates. In planters it also controls seed spacing in a row. A seed planter may be required to drop the seeds at rates varying across wide range Proper design of the metering device is an essential element for satisfactory performance of the seed planter. The seed metering device used for this work is the plastic vertical roller type with cells on its periphery. The size and number of cells on the roller depends on the size of seed and desired seed rate. In this design, the plastic vertical roller lifts the seeds in the cells and drops these into the seed funnel which is conveyed to the open furrow through the seed tube. Metering plate cells having different no of cells are 6 and 7 and diameter of the plates is 100mm. Shape of the cells are oblong with extension on its periphery and oblong. Seed metering plates were designed and then fabricated by 8 mm thick sheet of plastic fiber material.

2.3.1 Design of seed metering mechanism

The diameter of the metering mechanism was calculated using the formula [7]

$$D_r = \frac{v_r}{\pi n_r}$$

Where,

d_r = diameter of metering mechanism, cm

v_r = peripheral velocity of the metering mechanism, m s^{-1}

The number of slots on the metering mechanism periphery was calculated using the following formula

$$N_s = \frac{\pi \times D_g}{x \times g_r}$$

Where,

N_s = Number of slots on the surface

D_g = Diameter of ground wheel, cm.

x = Linear spacing of seeds on ground, cm

g_r = Gear ratio.

Gear ratio was determined using the following formula

$$g_r = \frac{\text{No.of teeth in metering shaft}}{\text{No.of teeth in motor shaft}}$$

Fig. 1 Seed metering plates

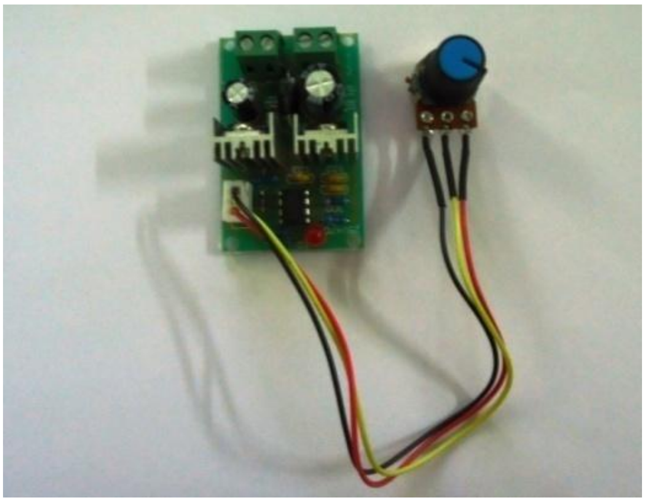

Fig. 2. DC Motor speed regulator

2.4 DC Motor

100 rpm side shaft super heavy duty DC Gear Motor was selected for operating the seed metering mechanism. It has a sturdy construction with large gears. Drive shaft is supported from both sides with metal bushes. Motor runs smoothly from 4V to 12V and gives 100 rpm at 12 V. Motor has 8 mm diameter, 19 mm length drive shaft with D Shape for excellent coupling. But, this motor will be bit noisy while running due to gear reduction.

2.5 DC Motor Speed Regulator

DC Motor Speed Regulator Controller Switch 12V/24V/36V was selected for regulating the speed of the motor. Selection of existing PCB was done by considering the electric power source (Battery) voltage and current.

DC motor speed controller was connected to the DC power supply voltage of 12V battery. Connect the battery terminals properly to the printed circuit board terminals as mismatching of terminals gets short circuit.

2.6 Power Transmission System

Power supply from DC power outlet of battery was connected to the DC Motor speed regulator controller circuit board input. Motor was connected to the printed circuit board. Power was transmitted equally (without reduction) to the metering shaft sprocket. Seed metering plates were mounted on the metering shaft to pick up the seed and deliver into the funnel which is connected to the seed delivery tube. Motor speed was controlled by dc motor speed controller circuit. Rotary potentiometer knob was used to set the required speed.

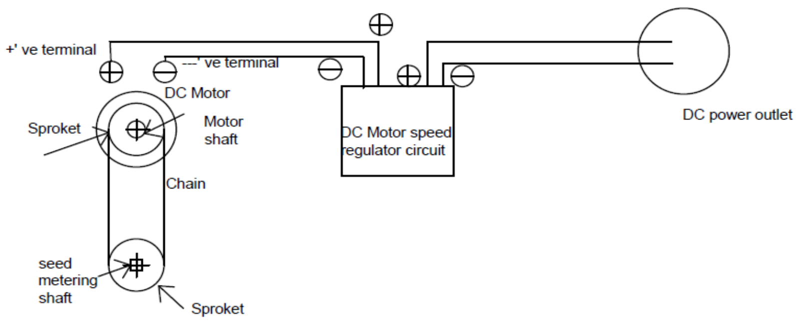

Fig. 3. Power transmission system

2.7 Seed Rate

Seed rate was determined by calibration in the laboratory. The seed rate for paddy seed was calculated by using the following formula.

Area covered= length travelled X implement width

Seed rate (kg ha^{-1}) = $\frac{seed\ dropped\ in\ area\ coverd\ X\ 10000}{area\ covered}$

2.8 Measurement of Seed Holding Ratio

In this research the single and double seed holding of the cells are counted manually. In this research the seed holding ratio was calculated for three varieties of maize namely Laxmi 2277, Goodrej Ultra and Tulasi Naga. The characteristics related to seeds are given in table 1. In the study, 2 speeds of seed plate(26 and 30 rpm), two types of oblong shape on with slot on the pickup of the seed and other with the extending on its periphery and number of cells on the seed plate are 6 and 7. The seed distance on row was selected as 23 cm for maize. The whole test is conducted manually only.

ANOVA factorial test is used for this study at a significant level of 5%

Seed holding ratio is calculated by using following equation [7]

SHR= $\frac{\text{total no of holes} - \text{EHN}}{\text{total no of holes}}\ X\ 100$

SSHR= $\frac{\text{total no of holes} - (\text{EHN} + \text{No of holes taken double seed})}{\text{total no of holes}}\ X\ 100$

DSHR= $\frac{\text{total no of holes} - (\text{EHN} + \text{No of holes taken single seed})}{\text{total no of holes}}\ X\ 100$

Where,

SHR is the seed holding ratio (%),

Total no of holes = no of revolutions of seed roller X no of cells on seed plate,

EHN is empty hole number.

3. RESULTS AND DISCUSSION

3.1 Performance Evaluation of the Seed Metering Unit

The performance evaluation of developed seed metering mechanism was conducted in terms of seed rate, seed holding ratio, single seed holding ratio, double seed holding ratio and results were discussed in the following sections.

3.1.1 Physical properties of maize seeds

The physical properties of the maize seeds measured were shown in Table 1.

3.2 Seed Rate

The planter was calibrated for seed rate and test results of calibration are presented here. The shape 1 represents extended oblong and shape 2 represents oblong.

3.3 Single and Double Seed Holding Ratio

The results are discussed here for the experiment conducted.

Fig. 4. Shapes of cells in metering unit
(a) Shape 1- extended oblong ;(b) Shape 2- oblong

Table 1. Physical properties of varieties of corn seed

Seed variety	Avg length, mm	Avg width, mm	Avg thickness, Mm	100 seeds weight, g	Avg bulk density, g/cc	Avg angle of repose, degrees	Moisture content, %
Local 1	9.367	8.184	5.68	26	0.6591	--	--
Local 2	9.282	8.189	5.182	24	0.7	--	--
Tulasi	9.103	8.396	5.913	24	0.7059	40.8	14.3
Laxmi	8.803	8.008	5.403	28	0.725	41.25	13.1
Goodrej	10.725	8.135	4.911	28	0.7143	39.8	12.4

Table 2. Single and double seed holding ratio for maize (variety Laxmi) with 7 cells

RPM	No. of revolutions for 2 min	Total no. of cells	Shape	Single seed	Double seed	Missing seed	S.S.H ratio	D.S.H ratio
26	53	371	Shape 1	140	13	205	0.38	0.04
				169	12	178	0.46	0.03
				122	10	229	0.33	0.03
						Avg.	**0.39**	**0.03**
			Shape 2	195	6	164	0.53	0.02
				180	3	185	0.49	0.01
				200	2	167	0.54	0.01
						Avg.	**0.52**	**0.01**
30	58	406	Shape 1	137	4	261	0.34	0.01
				130	3	270	0.32	0.01
				118	7	274	0.29	0.02
						Avg.	**0.32**	**0.01**
			Shape 2	361	19	7	0.89	0.05
				324	12	58	0.80	0.03
				315	7	77	0.78	0.02
						Avg.	**0.82**	**0.03**

Table 3. Single and double seed holding ratio for maize (variety Goodrej) with 7 cells

RPM	No. of revolutions for 2 min	Total no. of cells	Shape	Single seed	Double seed	Missing seed	S.S.H ratio	D.S.H ratio
26	56	392	Shape 1	64	4	320	0.16	0.01
				58	2	330	0.15	0.01
				66	7	312	0.17	0.02
						Avg.	**0.16**	**0.01**
			Shape 2	128	0	264	0.33	0.00
				130	0	262	0.33	0.00
				119	1	271	0.30	0.00
						Avg.	**0.32**	**0.00**
30	59	413	Shape 1	57	3	350	0.14	0.01
				60	6	341	0.15	0.01
				49	2	360	0.12	0.00
						Avg.	**0.14**	**0.01**
			Shape 2	117	1	294	0.28	0.00
				110	0	303	0.27	0.00
				100	0	313	0.24	0.00
				57	3	**Avg.**	**0.26**	**0.00**

Table 4. Single and double seed holding ratio for maize (variety Tulasi) with 7 cells

RPM	No. of revolutions for 2 min	Total no. of cells	Shape	Single seed	Double seed	Missing seed	S.S.H ratio	D.S.H ratio
26	53	371	Shape 1	98	0	273	0.26	0.00
				90	8	265	0.26	0.02
				102	10	249	0.27	0.03
						Avg.	**0.26**	**0.02**
			Shape 2	33	0	338	0.09	0.00
				31	0	340	0.08	0.00
				38	0	333	0.22	0.11
						Avg.	**0.13**	**0.04**
30	64	448	Shape 1	106	4	334	0.25	0.04
				100	5	338	0.23	0.03
				98	2	346	0.22	0.02
						Avg.	**0.23**	**0.03**
			Shape 2	28	0	420	0.06	0.00
				30	0	418	0.07	0.00
				25	1	421	0.06	0.00
						Avg.	**0.06**	**0.00**

Table 5. Single and double seed holding ratio for maize (variety Laxmi) with 6 cells

RPM	No. of revolutions for 2 min	Total no. of cells	Shape	Single seed	Double seed	Missing seed	S.S.H ratio	D.S.H ratio
26	52	312	Shape 1	211	5	91	0.69	0.03
				200	2	108	0.65	0.01
				192	7	106	0.64	0.02
						Avg.	**0.66**	**0.02**
			Shape 2	225	19	49	0.78	0.06
				200	17	78	0.70	0.05
				230	10	62	0.77	0.03
						Avg.	**0.75**	**0.05**
30	62	372	Shape 1	206	11	144	0.58	0.03
				200	10	152	0.56	0.03
				190	9	164	0.54	0.02
						Avg.	**0.56**	**0.03**
			Shape 2	336	14	8	0.94	0.04
				300	12	48	0.84	0.03
				341	10	11	0.94	0.03
						Avg.	**0.91**	**0.03**

3.4 Seed Holding Ratio

According to the formula the values of SHR are tabulated and then the 2^3 factorial test is carried at 5% level of significance. The test is done for three parameters at two different levels. The parameters were velocity of seed pate, shape of cell on seed plate and number of cells on seed plate. The levels of velocity taken are 26 and 30 rpm, shape of cells are oblong with extension on its periphery and oblong, numbers of cells are 6 and 7.

V represents the velocity of seed plate; S shape of the cell on seed plate and N represents the number of cells on the seed plate. VS combination of velocity and shape of cell, VN combination velocity and number of cells, SN combination of shape and number of cells and VSN is the combination of the velocity, shape of cell and number of cells.

Table 8 shows that there was significant change in seed holding ratio for the change in the velocity, shape of cell in seed plate and combination of both velocity and shape of cell on seed plate. The seed holding ratio also changes for the combination of velocity, shape of cell and number of cells on seed plate.

When the velocity of seed plate increased the seed holding ratio decreased, seed holding ratio also decreased with increase in number of cells on seed plate. Oblong shape with extension was suitable for these seeds.

Table 9 shows that there was significant change in seed holding ratio for the change in the velocity, shape of cell on seed plate, number of cells on seed plate, combination of velocity and shape of cell on seed plate and combination of shape and number of cells. The seed holding ratio also changes for the combination of velocity, shape of cell and number of cells on seed plate.

When the velocity of seed plate increases then seed holding ratio decreases, seed holding ratio also decreases with increase in number of cells on seed plate. Oblong shape is suitable for these seeds.

Table 6. Single and double seed holding ratio for maize (variety Goodrej) with 6 cells

Rpm	No. Of revolutions for 2 min	Total no. of cells	Shape	Single seed	Double seed	Missing seed	S.S.H ratio	D.S.H ratio
26	56	336	Shape 1	70	5	256	0.22	0.01
				60	6	264	0.20	0.02
				59	2	273	0.18	0.01
						Avg.	**0.20**	**0.01**
			Shape 2	121	0	215	0.36	0.00
				100	1	234	0.30	0.00
				130	4	206	0.39	0.00
						Avg.	**0.35**	**0.00**
30	59	354	Shape 1	76	13	252	0.25	0.04
				68	12	262	0.23	0.03
				78	12	252	0.25	0.03
						Avg.	**0.24**	**0.03**
			Shape 2	102	1	250	0.29	0.00
				110	0	244	0.31	0.00
				98	0	256	0.28	0.00
						Avg.	**0.29**	**0.00**

Table 7. Single and double seed holding ratio for maize (variety Tulasi) with 6 cells

RPM	No. Of revolutions for 2 min	Total no. of cells	Shape	Single seed	Double seed	Missing seed	S.S.H ratio	D.S.H ratio
26	53	318	Shape 1	72	9	228	0.23	0.03
				64	4	246	0.20	0.01
				79	2	235	0.25	0.01
						Avg.	**0.23**	**0.02**
			Shape 2	57	0	261	0.18	0.00
				60	0	258	0.19	0.00
				49	1	267	0.15	0.00
						Avg.	**0.17**	**0.00**
30	62	372	Shape 1	92	7	266	0.25	0.02
				100	10	252	0.27	0.03
				87	6	273	0.23	0.02
						Avg.	**0.25**	**0.02**
			Shape 2	38	0	334	0.10	0.00
				30	0	342	0.08	0.00
				29	0	343	0.07	0.00
						Avg.	**0.09**	**0.00**

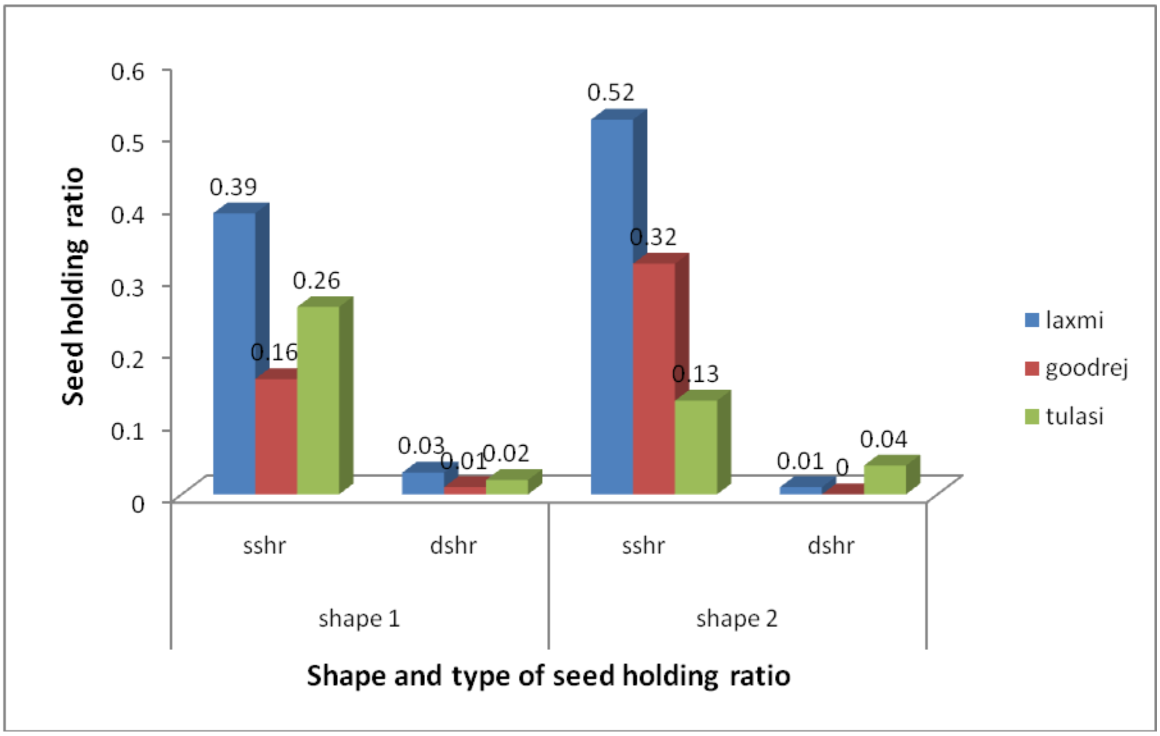

Fig. 5. Single and double seed holding ratio at two different shapes at speed of 26 rpm with 7 cells

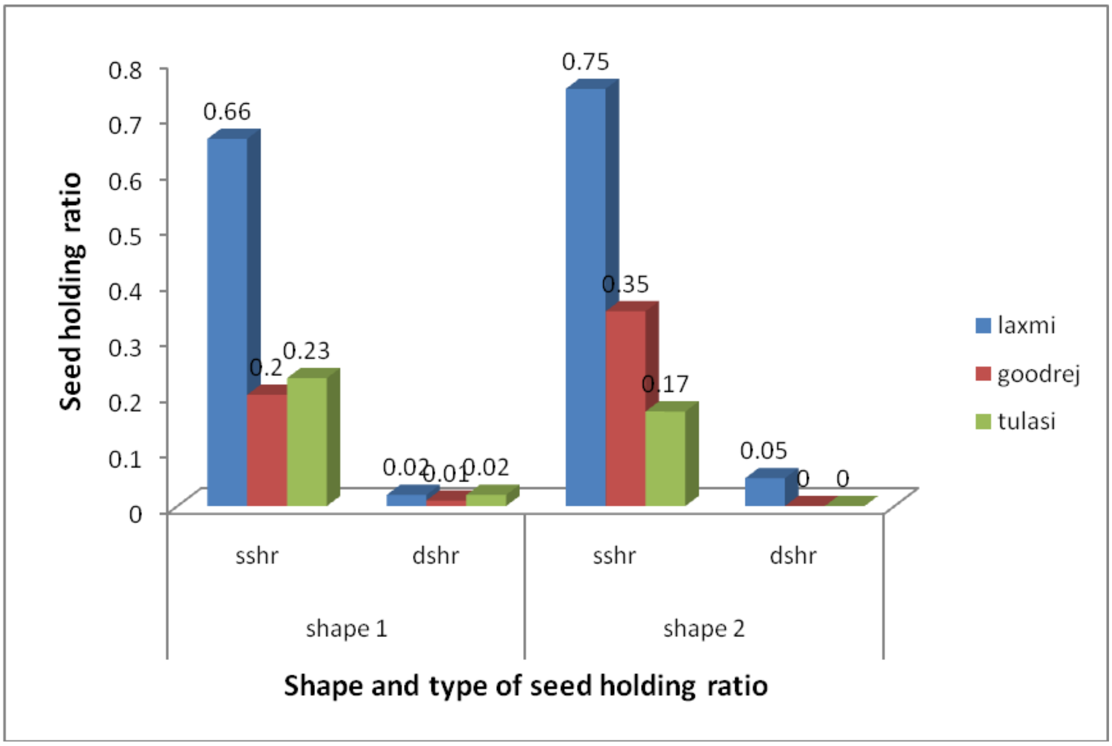

Fig. 6. Single and double seed holding ratio at two different shapes at speed of 26 rpm with 6 cells

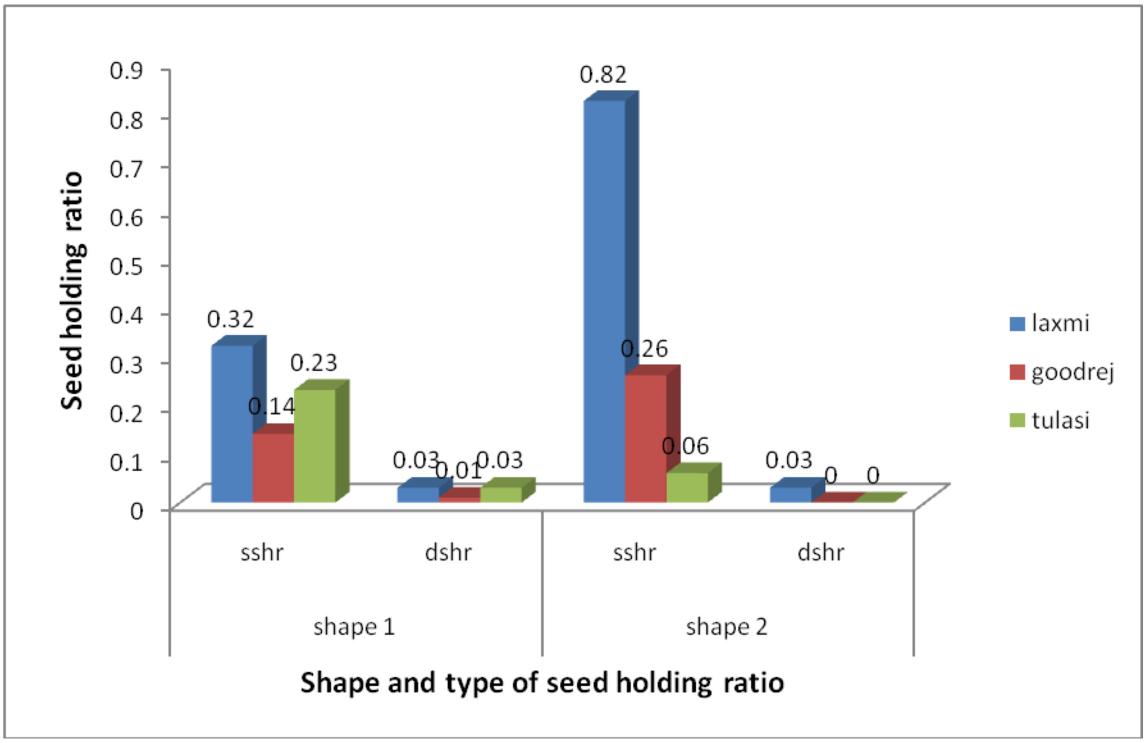

Fig. 7. Single and double seed holding ratio at two different shapes at speed of 30 rpm with 7 cells

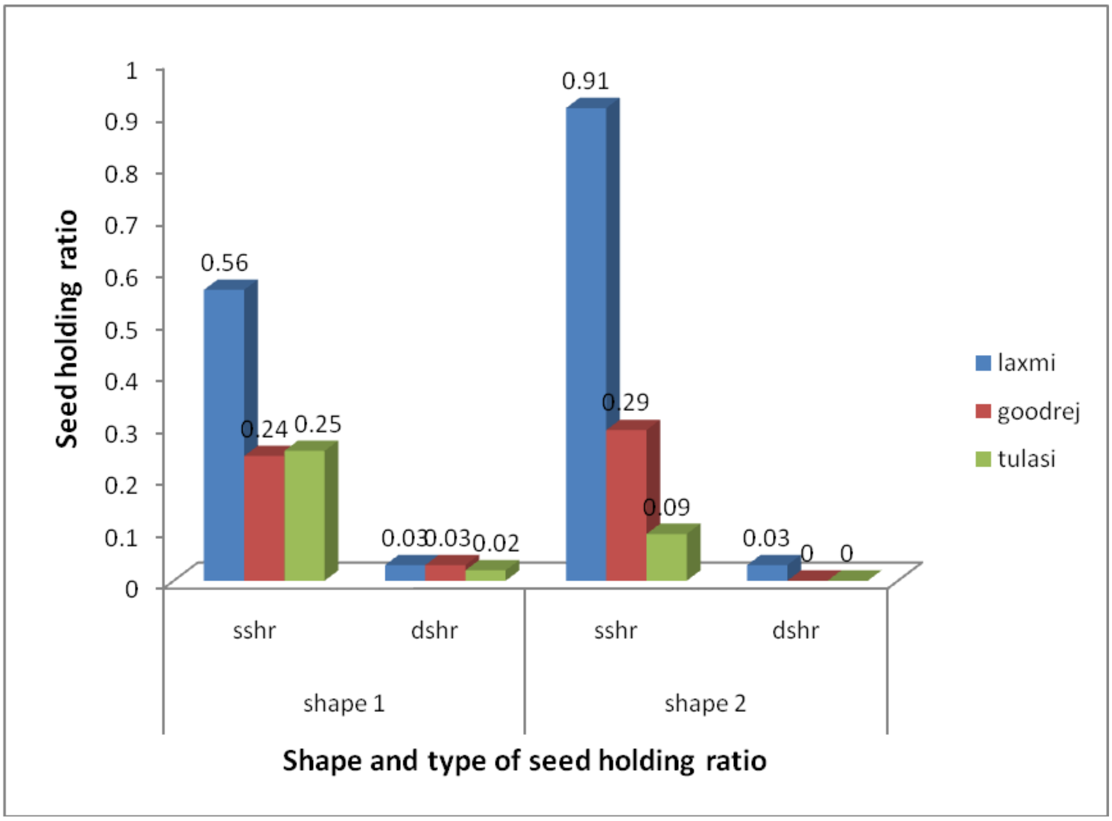

Fig. 8. Single and double seed holding ratio at two different shapes at speed of 30 rpm with 6 cells

Table 8. ANOVA table for maize seed variety: Tulasi Naga

source	Degrees of freedom	Sum of squares	Mean sum of squares	F-calculated	F-table
Replications	2	44.7	22.3		
Treatments	7	1990.1	284.3		
V	1	123.3	123.3	5.5*	4.6
S	1	322.7	322.7	14.3*	4.6
N	1	5.8	5.8	0.3(NS)	4.6
VS	1	1148.2	1148.2	50.8*	4.6
VN	1	9.9	9.9	0.4(NS)	4.6
SN	1	5.8	5.8	0.3(NS)	4.6
VSN	1	374.5	374.5	16.6*	4.6
Error	14	316.5	22.6		

Inference: As Fcal > Ftab value, main effects V, S, interaction effect VS, VSN are significant

Table 9. ANOVA table for maize seed variety: Goodrej Ultra

source	Degrees of freedom	Sum of squares	Mean sum of squares	F-calculated	F-table
Replications	2	9.4	4.7		
Treatments	7	1114.8	159.3		
V	1	436.1	436.1	81.75*	4.6
S	1	901.6	901.6	169.1*	4.6
N	1	61.1	61.1	11.5*	4.6
VS	1	3222.5	3222.5	604.1*	4.6
VN	1	19.6	19.6	3.7(NS)	4.6
SN	1	135.9	135.9	25.5*	4.6
VSN	1	373.7	373.7	70.1*	4.6
Error	14	74.7	5.3		

Inference: As Fcal > Ftab value, main effects V, N, S interaction effect VS, SN and VSN are significant

Table 10. ANOVA table for maize seed variety: Laxmi 2277

source	Degrees of freedom	Sum of squares	Mean sum of squares	F-calculated	F-table
Replications	2	104.5	52.25		
Treatments	7	8815.3	1259.33		
V	1	1761.3	1761.31	97.20*	4.6
S	1	29.9	29.93	1.65(NS)	4.6
N	1	1693.4	1693.44	93.45*	4.6
VS	1	194.9	194.94	10.76*	4.6
VN	1	116.2	116.16	6.41*	4.6
SN	1	146.0	146.03	8.06*	4.6
VSN	1	4873.5	4873.50	268.95*	4.6
Error	14	253.7	18.12		

Inference: as Fcal > Ftab value, main effects V, N, interaction effect VS, VN, SN and VSN are significant

Table 10 shows that there is significant change in seed holding ratio for the change in the velocity, number of cells on seed plate, combination of velocity and shape of cell on seed plate, combination of velocity of seed plate and shape of the cell and combination of shape and number of cells. The seed holding ratio also changes for the combination of velocity, shape of cell and number of cells on seed plate.

When the velocity of seed plate increases then seed holding ratio increases, seed holding ratio also increases with increase in number of cells on seed plate. Oblong shape is suitable for these seeds.

4. CONCLUSION

The highest and least value of seed holding ratio is 94% at a speed of 30 rpm in shape 2(6 and 7 cells) and 31% at a speed of 30 rpm in shape 1(7 cells), 39% at a speed of 26 rpm in shape 2(6 cells) and 12% at a speed of 30 rpm in shape 1(7 cells), 45% at a speed of 26 rpm in shape 1(6 cells) and 6%at a speed of 30 rpm in shape 2(7 cells) for laxmi, goodrej and tulasi variety of seeds respectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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