Madras Agric. J., 2019; doi:10.29321/MAJ 2019.000285

RESEARCH ARTICLE

Performance Evaluation of Projected Seed Cell Vertical Rotor Device for Pelleted Rice

G.Kalaivani[1] and D.Manohar Jesudas[2]*
Agricultural Machinery Research Centre, Tamil Nadu Agricultural University, Coimbatore - 641 003

Received : 9th May, 2019
Revised : 27th May, 2019
Accepted : 13th June, 2019

ABSTRACT

Rice is grown by transplanting under wetland conditions or by direct sowing depending upon the availability of water. In India, the total area under irrigated rice is about 22.00 million hectares, which accounts for about 49.5 per cent of the total area under rice crop in the country. Upland rice fields are generally dry and directly seeded. In India, the total area under upland rainfed rice is about 6.00 million hectares, which accounts13.5 per cent of the total area under rice crop in the country. Wet seeding of rice is practiced when there is insufficient time to prepare the nursery for transplanting or when the cost of transplanting of rice is too high. Sowing is done either by broadcasting or with equipment like drum seeder. Manually operated drum seeder has drawbacks like a scattering of seeds, dislocation of seeds due to surface water or rain and seeds being picked up by pests, etc. Asystem for accurately placing multiple seeds in hills will eliminate the above problems. Hence a method of sowing pelletized rice was developed. The seed pellets will be sown by a seeder in a wet rice field.In this present study, a projected seed cell vertical rotor device of 120 mm diameter with 12 cells on the rotor periphery was evaluated. The parameter used to evaluate the sowing performance were rotor speeds of 8, 11, 14, 16 and 20 rpm, seed sizes of 8 to 9 mm, 9 to 10 mm and 10 to 11mm diameter, cell sizes of 10, 11, 12 mm and three depths of seeds in hopper as 10, 20 and 30 mm above the disc center line. Due to the non singulation of seeds, 60 mm rotor was dropped. Hence 120 mm vertical rotor seed metering mechanism was selected for sowing in field condition.

Keywords: *Direct sowing, multiple seed pellet, Rice, projected seed cell vertical rotor*

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the principal food crops of the world. China is the leading rice producer followed by India, Indonesia and Bangladesh. The major rice-growing states in India areAndhra Prade sh,Telangana,Punjab,Chhattisgarh,Uttar Pradesh, Odisha,Haryana,Tamil Nadu,West Bengal,Madhya Pradesh, Uttarakhand. The total area under rice in India is over 99 million hectares with an annual production of 110 million tonnes and a share of TamilNadu is 17,25,730 ha with an estimated production of about 71,15,195 tonne. Major Rice production areas in Tamilnadu are the Cauvery delta zone like Thanjavur, Nagapattinam, Thiruvarur and Trichy.

Rice is grown by transplanting under wetland conditions or direct sowing depending upon the availability of water. In India, the total area under irrigated rice is about 22.00 million hectares, which accounts for about 49.5 per cent of the total area under rice crop in the country. Upland rice fields are generally dry and directly seeded. In India, the total area under upland rain fed rice is about 6.00 million hectares, which accounts13.5 per cent of the total area under rice crop in the country. Wet seeding of rice is practiced when there is insufficient time to prepare the nursery for transplanting or when the cost of transplanting of rice is too high. In wet seeding normally pre-germinated rice is sown in a puddle and drain fields. The sowing is done either by broad casting or with equipment like drum seeder. The main drawbacks of thedrum seeder for wet seeding are:

1. Seeds not sown in accurate location and hence plant spacing is not maintained
2. Scattered growth of 10 to 12 seedlings per hill thus leading to reduced yield, however, the recommended population is 2 seedlings per hill

*Corresponding author's e-mail: manohar.dmj@gmail.com

3. Seeds are sown in surface and get dislocated due to surface water or rain

4. Seeds being picked up by pests

A system for accurately placing multiple seeds in hills will eliminate the above problems and also ensure better stand per hill after taking the germination and establishment losses are taken into account. Rice seeds have a germination rate of around 90 % under best conditions. Hence if three seeds are sown in a hill, then the probability that a hill has no seedling established is 2.7% and the probability that there is one seedling per hill is 9.6 percentage and the probability of having two seedlings per hill will be 38.4 percentage and the probability for all three seeds to establish per hill will be 51.2 %. Hence the missing hills will be only less than 3%. Hence it is proposed to pelletize the rice seeds with three seeds per pellet. The seed pellets will be sown by a seeder in wet rice field. The objective of this study is to develop a complete system for preparing multi seed pellets for rice and equipment for sowing the same. A projected seed cell vertical rotor metering device was developed and evaluated.

MATERIALS AND METHODS

To develop the technology for pelletizing multiple seeds, multiple seeds were aggregated manually using a natural binding agent. A method of forming the pellets in batches of 81/batches using a semi-automatic method was also developed.The aggregated seeds were pelletized using a lab scale pelleting machine. The seeds were pelletized with natural clay and organic binding agent. The pelletized seed in bulk is shown in Fig 1. To confirm that there is no inhibition of germination by the pelletization process, a preliminary trial was conducted using a pot experiment. The experiment showed encouraging results. The physical properties of the pelletized seeds were measured using standard procedures and are tabulated in Table 1.Based on the physical properties, two types of vertical rotor seed metering devices designed and developed.

Development of seed hopper

The hopper was designed with an aluminum sheet of 1 mm thickness and the capacity of the device was 750 cc. The hopper was designed as a separate unit and the seed rotor was mounted independently of the hopper. Baffles were provided so that the seeds come into contact with the seed rotor only in the seed pickup zone.For metering the pelletized rice seeds, a metering device that can handle bold pelletized seeds, with minimum mechanical damage is required. The hopper can hold 500 g of pellets. Hence, for one fill of hopper, there will be around 1500 no. of pellets (300 g / 1000 sets) and at a spacing of 25 cm, each hopper can supply seed for 6000 m length.Fig 2.shows the cross-section of the metering hopper. The seed funnel was also provided to guide the seeds to the point of placement.

Design and development of vertical rotor seed metering device

To reduce the abrasion between the seed disc and the seeds, a vertical rotor type metering device was selected. The metering device should have positive cell filling action and easy discharge of seeds from the cell. Hence a vertical rotor with projecting cups at the periphery was selected to obtain the advantage of better cell fill of cup type metering mechanism and uniform release point of vertical rotor. The entire design of seed disc is based on the circle diameter.The diameter of the circle is 120 mm. Spherical shaped cells were formed to pick the seed from the seed hopper. The projected vertical rotor consisted of round shaped disc diameter of 120 mm, with a fixer hole on the inner diameter to maintain the metering rotor in a vertical position and obtain rotational movement. Twelve numbers of spherical shape slots on periphery of the metering rotor and these cells diameters are varying from 10 mm to 12 mm. Because of the pelletized seeds, diameters are varying from 8 mm to 11 mm. The vertical rotor seed metering disc was designed in 3D software and the entire seed meter rotor were made by 3 D printers (Fig 3).The performance of the projected vertical rotor was evaluated by varying the parameters tabulated in table 2.

The metering device for the pelleted seeds were designed to ensure minimum damage to seeds, free flow of seeds within the hopper, ease of mounting the hopper, and ease of fabrication. The seed disc was mounted on a common metering shaft made of 19.05 mm aluminum tube. The shaft was mounted on nylon bearings mounted on sheet metal supports. This design made it possible to mount the seed plate assembly independent of the hopper. To mount the seed plate to the hollow aluminum tube, a friction cone type mount was provided. This ensured that the clamping of the seed plate and the metering shaft is flush with the face of the seed rotor. The common seed metering shaft was driven through suitable timing belt drive between the geared DC motor and the metering shaft. Figure 4 shows the cross-section of the seed metering device with seed funnel.

Experimental set up to evaluated metering performance

A laboratory experimental set-up was developed to examine the influence of the selected variables, viz. peripheral speed of the seed-metering rotor, cell sizes, seed sizes and depth of seeds in the hopper on missing, singles, doubles and more than two seed metering (Panning et al. 2000, Jayan and Kumar 2003). An experimental set-up consists of 12 V DC motor, seed metering shaft timing pulley and belt, seed hopper, projected vertical seed rotor, speed control device and 12 V portable battery. Drive for the seed metering device are shown in figure 5. The DC motor speed was controlled by a speed controller and the forward speed of the seed metering device rotational speeds considered for the study are tabulated in Table 2.The response variables considered for the study were:

i. Missing index – percent of seed hills devoid of any seeds.

ii. Singulating performance – percent of hills having a single seed.

iii. The occurrence of more than two – percent of hills having multiple seeds.

RESULTS AND DISCUSSION

The geometry of seed pellet plays a major role in the design of the metering rotor and the flow of seeds through seed planter components. The

Figure 1. Rice seed pellets with three seeds

metering device was evaluated through test runs that werereplicated five times.Based on the observed values, the two main operational parameters that

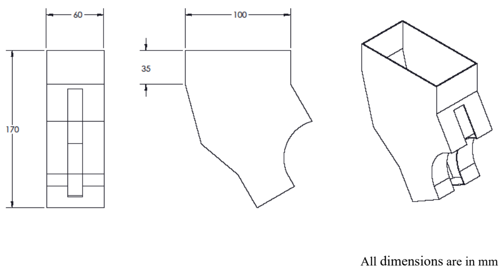

Figure 2. Cross section seed hopper

influenced the metering performance were found to be the speed of a metering rotor and the level of seeds in the hopper. The values for all speeds, level of seeds in the hopper, seed sizes and cell sizes were pooled and the relation between the percentage of singles, missing and double seeds metered were analyzed.

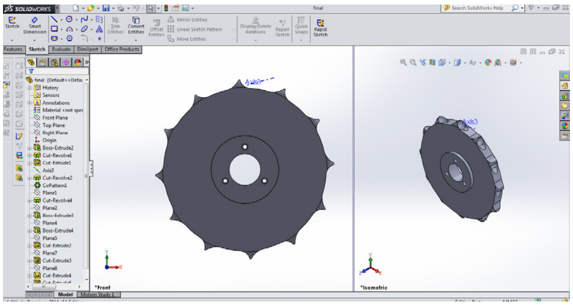

Figure 3. Development of projected seed cell vertical rotor

Effect of operating speed on seed metered

Laboratory experiments were carried out at different speeds of seed disc. The observation as missing, singles and more than two pellets was tabulated.

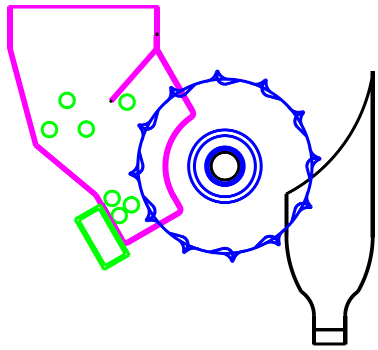

Figure 4. Seed metering device with seed funnel

It was observed that the average single seed metered by different types of seed rotor cavity was 97.1, 96.7 and 96.1 percentage respectively at rotor peripheral speed of 25.12, 34.54, 43.96, 53.38 and 62.80mm per sec.

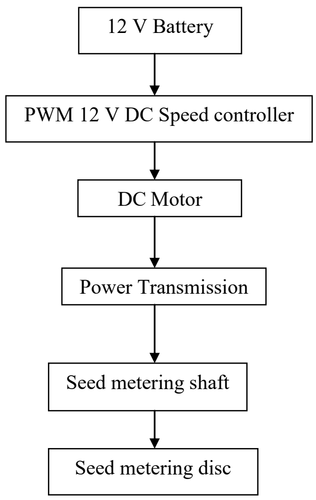

Figure 5. Drive for seed metering device

The corresponding forward speed of 0.72, 0.99, 1.26, 1.53 and 1.8 kmph respectively. It was observed that with an increasing forward speed (speed of vertical rotor metering disc) the seed singulation also increased.

The two main operational parameters that influenced the metering performance were the speed of the metering rotor and the level of seeds in the hopper.

Table1. Physical properties of multiple pelleted rice (CO51) seeds used in the experiment

Samples	Number of observation	Mean value	Standard deviation	Minimum value	Maximum value
Diameter(mm)	100	9.142	0.449	7.738	10.488
1000 seed weight(g)	10	299	8.788	310	280
Bulk density(g/cc)	10	497.942	0.534	497.00	499.00
True density(g/cc)	10	751.294	0.890	749.59	752.34
Porosity (%)	10	33.721	0.128	33.493	33.882
Angle of repose (degree)	5	31.964	3.875	26.56	36.69

The values for all seed sizes and cell sizes were pooled and the relation between the percentage of singles as a function of rotor speed and level of seeds in hopper were obtained.

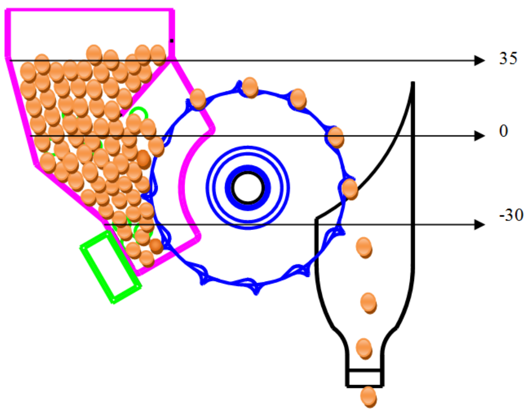

Figure 6. Different levels of seeds in seed hopper

Different levels of seeds in the seed hopper are shown in figure 6 for obtaining the optimum level of seeds in seed hopper. The levels are marked on the inside wall of hopper and were manually topped up.

However, it was observed that depths of pellets in hopper alone had a significant influence on single pellet metering.From the Figure 7, it was inferred that the depth of seeds in hopper' 0'level had the highest values of singles of 97.10 per cent followed by 96.7 per cent and 96.1 per cent at the rotor peripheral speed of viz., 53.38, 43.96 and 34.54 mm per sec respectively.

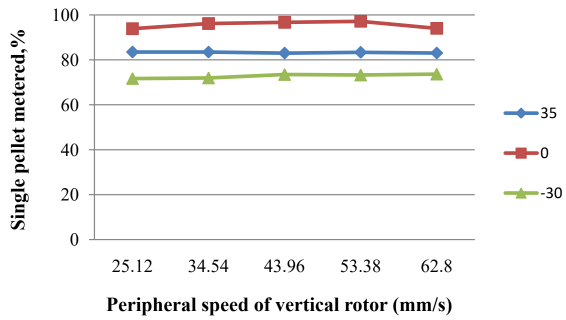

Figure 7.Effect of operating speed on single seed metered

It was also observed that depth of seeds in the hopper -30 levels had the lowest percentage of

Table 2 Parameters for evaluation of 120 mm rotor

SI.No	Parameter	Parameter Value				
1	Seed size, mm	8 to 9	9 to 10	10 to 11		
2	Cell cavity diameter, mm	10	11	12		
3	Level of pellets in Hopper, mm	35	0	-30		
4	Peripheral seed of rotor speed, rpm	4	5.5	7	8.5	10

singles 71.1 per cent at the rotor peripheral speed of 25.12mm per sec respectively.It was inferred that the percentage of single pellet metered was constant when the depth of seeds in hopper was 35 with all the five rotor peripheral speeds.

The effect of speed of the vertical rotor of pelleted on missing seeds at selected levels of cell geometry is shown in Figure 8.

It is observed that the percentage of missing increased from15.77 to 17.62 with a decrease in depth of seeds in the seed hopper -35 levelsfor all the three selected levels of cell geometry and for all vertical rotor speeds. The lowest percentage of missing seeds was observed at the rotor peripheral speed of 53.38 mm per sec at 0 levelsof seeds in the seed hopper...It was inferred that when the depth of seeds in the hopper was 35 mm, the percentages of missing cells were constant, with all the five rotor peripheral speeds.

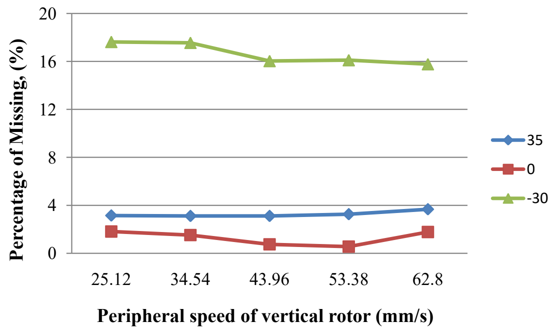

Figure 8. Effect of operating speed on missing seeds

The interaction of factor means revealed that as the depth of seeds in the hopper was increased, the more than one seeds metered also increased (Fig. 9).

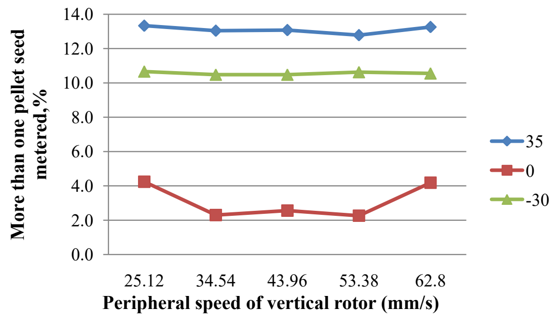

Figure 9.Effect of operating speed on more than one seeds metered

It was inferred that 35 mm level of seeds in seed hopper was given the highest percentage of more than two seed metered. This might have been due to the increased seeds in the seed hopper. Hence comparing all the combinations, 0mm level of seeds in the hopper at the rotor peripheral speed of 53.38 mm per sec is more suitable than the other levels depth of seeds in the hopper which can be considered for further studies.

CONCLUSION

The developed projected seed cell vertical rotor metering mechanism was distributed the pelleted seeds uniformly. From the observation, it was concluded that the level of fill in the hopper influenced the metering of singles more than the speed of the rotor. Also, it was observed that when the level of fill was optimum, the performance of the metering device was not much influenced by the rotor speed and another influencing factor. All the depth of seeds in the hopper levels was performed better with peripheral speeds of the rotor. This shows that 0 mm depth of seeds in the hopper is more suitable than the other depth of seeds in the hopper.

ACKNOWLEDGMENT

We wish to thank the Council of Scientific and Industrial Research (CSIR) for providing the funds used to conduct this research. This study was conducted at Tamilnadu Agricultural University, Coimbatore. The technical support provided by the Agricultural Machinery Research Center, TNAU is highly acknowledged.

REFERENCES

Bashiri, M., Ode, D.A., and Ogwuche, E.U. 2013. Development of a hand planter. *JORIND*,(11): 1-6.

Jayan P R and Kumar V J F. 2004.Planter design in relation to the physical properties of seeds. *Journal of Tropical Agriculture,* 42 (1/2): 69–71.

Kepner R A, Roy Bainer R and Barger E L. 1978. Principles of Farm Machinery, 3rd edition. AVI publishing company Inc., Westport, C T:

Olajide, O. G. and Manuwa, S. I. 2014. Design, Fabrication and Testing of a Low-cost Row-Crop Planter for Peasant Farmers. Proceedings of the International Soil Tillage Resear`chOrganisation (ISTRO) Nigeria Symposium, Akure 2014 November 3 - 6, Akure, Nigeria, pp. 94–100.

Panning J W, Kocher M F, Smith J A and Kachman S D. 2000. Laboratory and field testing of seed spacing uniformity for sugar-beat planters. *Applied Engineering in Agriculture,* 16(1): 7–13.

Sahoo, P.K. and Srivastava, A.P.2000.Development and performance evaluation of okra planter.*J. Agric. Engg.*,37(2):15- 25.

Zeliha, B.B. and Aziz, O. 2004.Effect of different operating parameters on seed holding in the single seed metering unit of a pneumatic planter. Turkish *Journal of Agriculture and Forestry*, 28:435-441