International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 9, 2019, pp.-8382-8386.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

STUDY ON MULTIPLE SEED PELLETING OF RICE (*ORYZA SATIVA* L.) SEEDS

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Received: May 02, 2019; Revised: May 11, 2019; Accepted: May 12, 2019; Published: May 15, 2019

Abstract: This study was aimed at development of an alternate rice seed planting method instead of direct sowing of bare rice seeds. CO51 variety rice seeds were bound pelleted and prepared for planting. Bare rice seeds (three) were collated and bound with glue manually and were pelleted with a special pelleting mixture in a pelleting device and then germination tests were carried out for both bare and pelleted seeds. The physico-mechanical properties of bare rice seeds, bound rice multiple seeds (three) and pelleted rice seeds such as length, width, thickness, sphericalness, bulk density, true density, thousand weight of grains, coefficient of static friction, porosity, angle of repose, pelletization efficiency, fragmentation test, dissolution time in water, number of seeds in pellet, were measured. Germination tests were done in pot culture for bare rice seeds, bound rice multiple seeds (three) and multiple pelleted rice seeds. The study shows that, planting pelleted seeds led to equal emergence rate compared with bare rice seeds. This study showed that using the pelleted seeds result in more favorable crop than bare rice seeds. Moreover, pelleted rice seeds could be used for mechanized seeding as the pelleting could withstand the crumbling effect of the seeder's metering mechanism.

Keywords: Germination of pelleted rice, Pelleted seeds, Pelleting multiple seeds, Physico-mechanical properties, Rice seedling

Citation: Kalaivani G. and Manohar Jesudas D. (2019) Study on Multiple Seed Pelleting of Rice (*Oryza sativa* L.) Seeds. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 9, pp.- 8382-8386.

Introduction

In Asia where 95 percent of the world's rice is produced and consumed, it contributes 40-80 percent of the calories of Asian diet. Rice is the basic food for two-thirds of the world population and is the most important cereal crop cultivated in the world. Rice crop is considered one of the most important food and export crop in India. China is the leading rice producer followed by India, Indonesia and Bangladesh. The major rice growing states in India are Andhra Pradesh, Telangana, Punjab, Chhattisgarh, Uttar Pradesh, Odisha, Haryana, Tamil Nadu, West Bengal, Madhya Pradesh and Uttarakhand. The total area under rice in India is over 99 million hectare, with an annual production of 110 million tonnes and share of Tamil Nadu is 17,25,730 ha with an estimated production of about 71,15,195 tonnes [1]. Irrigated ecosystems provide 75percent of global rice production. In India, the total area under irrigated rice is about 22.00 million hectare, which accounts about 49.5percent of the total area under rice crop in the country. The common method of planting rice in irrigated ecosystems is transplanting. Upland rice fields are generally dry, unbunded, and directly seeded. In India, the total area under upland rain fed rice in the country is about 6.00 million-hectare, which accounts13.5percent of the total area under rice crop in the country. Mechanization in direct sowing of rice is negligible because of the sinkage problem of low land areas and small land holding. The rice plants are transplanted with spacing of 25cm × 25cm or randomly by women labours. Manual transplanting is labour and time-consuming operation. Currently human labour shortage is a major problem causing increase in time of operation and cost of cultivation. The registered rice seeds (CO51) that are widely produced in Tamil Nadu were used in the experiment. Properties of rice seeds (Length, Width, Thickness, Sphericalness, Dissolution time in water, Number of seeds in pellet, Bulk density, True density, and thousand weights) were studied.

Materials and methods

Selection of the varieties

The long grain local variety of rice named, CO51, was used in the present study. Rice was cleaned manually to remove all foreign and broken or immature grains.

Seed quality upgradation by egg floating method

A bucket of clean water has to be taken and, in that water, fresh egg which sinks to the bottom has to be taken. To the clean water with egg outside slowly the common salt were added to a level at which the egg floats at top exposing 2.5 cm of its shell. The egg is removed and the rice seeds were dropped into the solution which separates as sinker and floater. the sinkers are good seeds while the floaters are less vigorous and dead seeds. The floaters are removed [2].

Forming bound multiple seeds

Initial trail to evaluate the pelletability of multiple bound seeds was done by manually sticking together three individual rice seeds so that they form the length wise bundle. Commercial polymerizing type additives as well as organic weed flour paste were used for sticking the seed together. Since, the quality of seeds required for practical adoption of technology in the order of 1, 60,000 seed pellets per hectare. The possibility of developing a semi-automated system for bounding the seeds was examined. Seeds were randomly dropped through the funnel having the stem diameter of 5 mm. The bottom of the stem of the funnel was made flat, the seeds aligned them self length wise and collated at the base of the stem. Then the drop of additive is applied and the bound seed aggregates were ejected from the funnel. System for automating this process using multiple funnel like cavities and combined with automatic seed pick and drop mechanism is being designed. [Fig-1a] and [Fig-1b] shows the process of bound seeds aggregates.

Pelletization of seed aggregates

The pelletization of the collates aggregates was done in a lab scale pelletizing device[10].

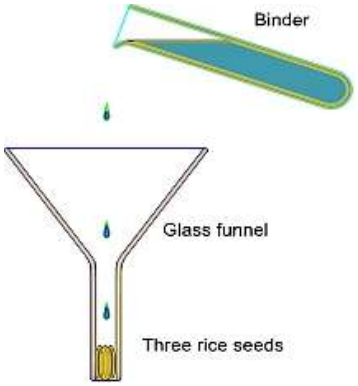

Fig-1a Seed aggregating process

Fig-1b Bound multiple seed aggregates

The experimental pelletizing device shown in [Fig-2]. These devices consist of 20 mm diameter of aluminium pan, rotated at a speed of 43 rpm through the dc motor. The angle of inclination of the axis of pan was 30°.

Fig-2 Seed pelleting machine

Fig-3 The bulk pelleted seeds

This setup can be used for pelletizing 200 grams of seed aggregates per hour in batch. Time taken for pelletizing one batch was one hour, process of pelletization adopted similar to (Tamilselvi and Manohar jesudas, 2017) 200 grams of bound seed aggregates 4000 having numbers was added to the pan with 900 grams of pelleting medium. The water was used as binding material. The water sprayed continuously as the pelletization proceeds. This process is continued for 30 minutes and the contains are emptied and allowed to set for few hours. Then they formed pelletized were separated by sieving and again added to the pan with pelleting medium and the process is repeated 2 more times. The bulk pelleted seeds formed by seed pelleting machine shown in [Fig-3]. The process of forming single seed to multiple seed pellet shown in [Fig-4].

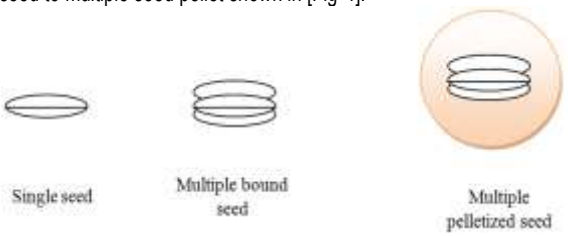

Fig-4 Process of forming single seed to multiple seed pellet

Size and shape of the seed

Digital microscope Dino Lite 2.0 was used to measure the size of rice seeds [Fig-5a]. In order to get the image of the seed, the seed was placed in rest position (horizontal) over dark back ground and placed under the microscope and the image was obtained. The dimensions of the randomly selected hundred seeds were recorded for CO51. The geometric mean diameters (Dg) of the seeds were calculated using the following relationship [9]. The thickness (minimum lateral diameter) was measured using a digital Vernier calliper [Fig-5b].

$$D_g = (LWT)^{1/3} \quad (1)$$

Where, L is the length of the grain in mm; W is the width of the grain mm; T is the Thickness of the grain in mm.

The Spherecity (φ)of the grain was calculated using the following equation (Jha, 1999).

$$\Phi = ((LWT)\ ^\wedge 1/3)/L \quad (2)$$

Thousand seed weight

Test weight was determined for five random samples of each variety on an electronic balance having least count of 0.001g.

Bulk density

The bulk density was computed by measuring the weight of seed that can be filled in to a cylindrical aluminium cup of 10cc. This procedure was replicated thrice and the average value of the weight per unit volume was computed.

Bulk density = Weight of the sample(g)/ volume of the sample(cc) (3)

Fig-5a Dino Lite 2.0 Digital microscope

Fig-5b Thickness of pelleted seeds measured by digital Vernier calliper

True density

The water displacement method was used to determine the true density of the single seeds and bare seed aggregates. For the pelleted seeds, the seed was coated with grease to avoid it hydrophobic and then volume was found by water displacement method. True density has been defined as the ratio of mass of the seeds to the true volume of displaced water [9][12]. The true density was obtained by measuring 50g of rice seeds and filling into a 50ml of distilled water, thus the difference in liquid displacement was noted down and average of 3 replications was recorded.

$$TD = (W/V) \quad (4)$$

Where, TD is the true density, W is the weight of the sample and V is the displaced volume.

Porosity

The porosity is the measure of unconsolidated mass of material. It was calculated by using the following relation.

$$Porosity = ((TD - BD) / TD) \times 100 \quad (5)$$

Where, TD is the true density and BD is the bulk density.

Angle of repose

For measuring the angle of repose, a rectangular box (100mm width and 150mm length) with removable front panel was used. The box was filled with the seeds, and then the front panel was quickly removed, allowing the seeds to flow and assume a natural slope. The height of grain pile retained on the circular disc was measured and used to determine the angle of repose [3]. The height of the heap (h) and the radius of the heap (r) were measured with the help of measuring scale and the angle of repose (w) of rice seed was computed using eq. 6 [9].

$$\omega = \tan^{-1}(h/r) \quad (6)$$

Where, w is the angle of repose in degree, h is height of heap in cm and r is the radius of heap, cm.

Coefficient of static friction

The static coefficient of friction against different surfaces was determined using a cylinder of diameter 94 mm and depth 98 mm filled with grains. With the cylinder resting on the respective surface, the surface was raised gradually until the filled cylinder just started to slide on the flat surface. Flat surfaces consisting of stainless steel, galvanized metal sheet, aluminium and rubber plates were used in order to measure the static coefficient of friction of the seeds. In order to measure the static coefficient of friction of bare seeds, the bare seeds were placed upright, upside down and parallel to the surface on flat surfaces. However, as pelleted seeds have spherical forms, the static coefficient of static friction was measured by taking their forms into account. The co-efficient of static friction was calculated as the ratio of frictional force to the normal force as,

$$\mu = F/N \quad (7)$$

Where, μ is the co-efficient of friction, F is the Frictional force in kg and N is the normal force in kg.

Pelletization Efficiency

One hundred pelleted rice seeds were randomly selected after treatment. All pellets were soaked one by one in water to find out the presence of seed / seeds inside the pellet [2]. The pellets with seed(s) were counted and pelletization efficiency was calculated as:

Pelletization efficiency(%)=(Number of pellets containing seed)/(Number of pellets prepared)×100 (8)

Fragmentation test

The fragmentation test was done by taking 100 seeds in a plastic bag and shaking the seeds manually for one minute. Ten replications of 100 seeds for each treatment were tested. The fragmentation was evaluated visually and the total number of cracked or broken pellets was counted [10].

Dissolution rate

High dissolution rate in water is a desired characteristic of pelleted seeds. Pelleted seeds having bigger diameters had longer dissolution time in water related to materials used for pelleting. Longer dissolution time lags the absorption of moisture by the seed and inhibits germination [5]. Ten randomly selected pelleted seeds were dropped in water one by one. Time taken to dissolve the pelleted seeds in water was noted.

Germination Tests

Pelleting was done using the Bentonite clay powder. Because of binding nature of clay with the seed, Bentonite clay was used at the particular moisture content of about 80%. Water was used as Binding agent. Seed pelleting was done at the particular moisture content followed by drying at the room temperature. By examining all the samples, each sample should contain three seeds per pellet. Seeds were pelletized up to a diameter of 7 to 10.5 mm. The bare seeds, pelletized and non-pelletized seeds were tested under pot culture for germination performance. In order to check the germination efficiency of bare seeds, pelletized and non pelletized seeds, the pot culture experiment was done. The soil used for the experiment is Sandy clay loam and it was taken from the wet land (WL) areas of Tamil Nadu Agricultural University, Coimbatore. Twenty four pots were taken for this test with two kg of soil per pot. This soil was thoroughly puddled manually similar to field preparation in case of rice. The bare, multiple bound and pelletized seeds were sown on the pots and watered regularly and germination of the seedlings was observed, the experiment was done with 3 treatments and 8 replications, in each pot 25 hills were planted [Fig-6].

Fig-6 Germination rates of the bare seeds, bounded multiple seeds and pelletized multiple seeds (%)

Result and discussion

Seed characteristic

The length of the bare rice seeds used in the experiment ranged from 6.353 mm to7.747 mm [Fig-7]. Maximum and minimum values are 2.629 mm and 1.646 mm for width, 1.85 mm and 0.60 mm for thickness, 3.913 mm and 3.385 mm for geometric mean diameter and 53.992 and 45.916 % for sphericalness [Table-1]. Weights of one thousand kernel bare rice seeds are between17.58 and 16.78 g depending on diameter and mixture rate. Length of the pelleted rice seeds ranged between 7.738 mm to 10.488 mm [Table-2]. Thousand kernel weights of multiple pelleted seeds vary between 280 to 310 g per 1000 seed. The angle of repose of multiple pelleted rice seed was in the range of 26.56 to 36.69°. The angle of repose for pelleted rice was significantly less than that of bare rice seeds. The reason for the increased angle of repose of bare seed was due to the shape of the seed and the surface texture. The results of the multiple pelleted seed size of rice are presented in [Fig-8]. Most seed sizes of the rice samples were in the range of 7.738 to 10.488 mm, which is within the range of 7.0-10.5 mm. Hence the samples were passed through sieves to obtain uniform pellets. [Table-3] shows coefficient of static friction of the bare and pelleted seeds which were calculated with the help of flat surfaces composed of stainless steel, galvanized metal sheet, aluminium and rubber plates. Pelleting decreased the coefficient of static friction of the seeds. For above all surfaces, coefficient of static friction values is minimum at stainless steel surfaces. Number of seeds per pellet is an important criterion. Pelletization was done with aggregated and bounded seeds of three seeds per aggregate. However, during the pelletization process, some of the seed aggregates dis integrate and the average number of seeds per pellet was less than three [Table-3]. The pellet with two seeds was 10 percent while rest were three seeded pellets [5]. Multiple seeds were bounded with adhesive. Pelletization efficiency of the seeds used in the experiment was98.2 percent.

Table-1 *Physical properties of bare rice (CO51) seeds used in the experiment*

Samples	Number of observation	Mean value	Standard deviation	Minimum value	Maximum value
Length(mm)	100	7.16	0.318	6.353	7.747
Width(mm)	100	2.145	0.118	1.646	2.629
Thickness(mm)	100	1.7	0.128	0.6	1.85
Geometric mean diameter(mm)	100	3.67	0.121	3.385	3.913
Sphericalness (%)	100	51.292	1.085	45.916	53.992
1000 seed weight(g)	10	17.22	0.219	16.78	17.58
Bulk density (kg m^{-3})	10	451.134	0.533	450.23	451.68
True density (kg m^{-3})	10	1190.44	64.576	1127.74	1289.47
Porosity (%)	10	62.004	2.035	60.019	64.989
Angle of repose (degree)	5	34.791	0.876	33.42	36.12

Table-2 *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	499
True density(g/cc)	10	751.294	0.89	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

Table-3 *Coefficients of static friction rice (CO51) on different surfaces*

Surface	Bare seeds				Pelleted seeds			
	Mean value	Standard deviation	Minimum value	Maximum value	Mean value	Standard deviation	Minimum value	Maximum value
Stainless steel	0.31	0.015	0.299	0.321	0.116	0.009	0.11	0.122
Galvanized metal sheet	0.117	0.023	0.1	0.133	0.216	0.008	0.211	0.221
Aluminum	0.235	0.013	0.226	0.245	0.201	0.003	0.198	0.203
Rubber plates	0.249	0.013	0.24	0.259	0.187	0.008	0.182	0.192

Table-4 *Pelletization efficiency, dissolution time, fragmentation and number of seeds per pelleted seeds used in the experiments*

Sample	Pelletization efficiency (per cent)	Dissolution time (sec)	Fragmentation (no per 100)	Average number of seeds per pellet
CO 51	98.2	140	15.25	2.9

Table-5 *Germination rate of the bare seeds, bounded multiple seeds and pelletized multiple seeds (%)*

Treatment	No of triples	No of doubles	No of singles	No of complete failures	Equivalent single seed emergence
Base single seeds	152	41	7	0	91
Aggregated seeds	151	42	7	0	91
Pelletized multiple seeds	147	40	12	1	90

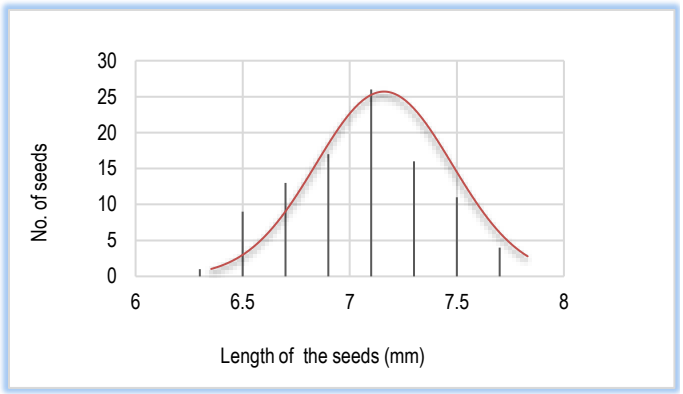

Fig-7 Average length of bare rice seeds

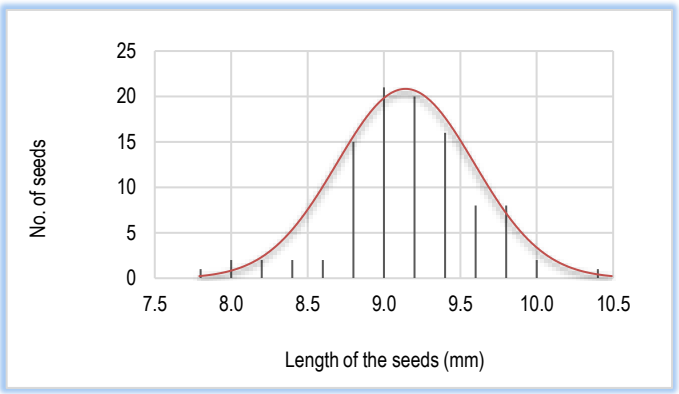

Fig-8 Average length for the multiple seed pellets of rice

Dissolution rate in water is a desired characteristic of pelleted seeds. The dissolution rate of pelleted seeds in water was represented in [Table-4] (between 7.738 mm and 10.488 mm diameter). Pelleted seeds having bigger diameter had longer dissolution time in water. The average values of fragmentation test of pelleted seeds were 15.25. Hence out of 100 pellets, only 15 to 16 seeds were fragmented under test.

Germination Tests

[Table-5] shows the results of Germination rate of the bare seeds, bounded multiple seeds and pelletized multiple seeds. Germination rate of the bare seeds, bounded multiple seeds and pelletized multiple seeds were recorded with eight replications for each.

The result shows that there is no difference in germination rate between bare, bounded multiple and pelletized seeds.

Conclusion

A technique of forming multiple seed pellets of rice by bounding three rice seeds and pelletization with suitable fillet was developed. The process of pelletization was standardized. The physical properties of the rice seeds used for pelletization were measured and reported. The seed aggregates formed by three seeds were also measured and their physical properties were evaluated. The seed pellets of multiple seeds were studied in order to find their physical properties and behavior in a seed planter. The efficiency of pelletization is 98.2 percent, and the dissolution time is 140 seconds.

Application of research: Study of evaluation the germination of multiple seeds, multiple bound seed and pelletized seeds were evaluated through pot culture

Research Category: Seed Pelleting

Acknowledgement / Funding: Authors are thankful to Scientific and Industrial Research (CSIR) for providing the funds used to conduct this research. Authors are also thankful to Agricultural Machinery Research Centre, Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India

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University: Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu
Research project name or number: PhD Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Tamil Nadu

Cultivar / Variety name: Rice (*Oryza sativa* L.) - CO51

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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