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Study on engineering properties of paddy seeds for the design and development of a drone based seeding mechanism for paddy crop

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Abstract

The study was conducted to develop a drone based seeding mechanism for paddy cultivation. Prior to the design process, the engineering properties of paddy seeds were thoroughly investigated. Specifically, the physical and mechanical characteristics of the RNR 15048 paddy variety were analyzed to obtain essential design parameters for key components such as the seed box, seed metering and shooting mechanisms. The experimental investigations were carried out in the department of Farm Machinery and Power Engineering, College of Agricultural Engineering, UAS, Raichur. Various physical and mechanical properties such as seed size, sphericity, moisture content, bulk density, true density, thousand seed weight, angle of repose and coefficient of friction were analyzed using standard procedures. The average length, width, and thickness of paddy seeds obtained were 7.61 mm, 1.60 mm and 1.12 mm, respectively, with a mean equivalent diameter of 4.58 mm. The mean sphericity was 0.31, indicating a slender grain shape of paddy seeds. The average moisture content was 9.71%, bulk density 515.74 kg/m³ and true density 1215.38 kg/m³. The thousand-seed weight was 12.23 g, while the angle of repose and coefficient of friction were 35.50° and 0.55, respectively. These engineering parameters are critical for optimizing the design of seed box, seed metering and shooting mechanisms in drone based seeding system, ensuring efficient seed flow, reduced breakage, and uniform seed distribution during drone based sowing operations.

Keywords: Paddy seeds, engineering properties and drone based seeding

Introduction

Rice, the primary staple crop, supports the livelihood of millions of rural households in India and plays a crucial role in ensuring national food security. Traditionally, rice cultivation is carried out in puddled fields using the transplanting method. However, direct-seeded rice (DSR) has emerged as an alternative approach that requires less water and labour compared to conventional transplanting. In this method, seeds are sown directly into a prepared field rather than raising seedlings in a nursery and transplanting them later.

Sowing, which involves placing seeds in the soil at appropriate depth and spacing, is a critical operation for achieving higher crop yields. Over time, sowing techniques have evolved from manual practices using hands, stones, and simple tools to the use of mechanized seed drills and planters. Despite these advancements, traditional manual seeding often leads to irregular seed placement and non-uniform row spacing, ultimately affecting crop performance (Kumar *et al.*, 2015) [5].

Mechanization in paddy cultivation has advanced significantly, yet manual and traditional methods of seed sowing remain labour-intensive, time-consuming and less efficient (Song 2018) [13]. With the increasing adoption of drone technology in precision agriculture, aerial seeding offers a promising alternative for timely and uniform sowing operations, particularly in waterlogged or inaccessible fields. To design an efficient drone-based seed sowing mechanism, understanding the engineering properties of paddy seeds is crucial (Mai *et al.* 2019) [7]. These properties directly influence the design and performance of key components such as the seed box, metering device, and shooting mechanism. Parameters like seed size, sphericity, bulk and true density, angle of repose, and coefficient of friction (Dahare *et al.*, 2019) [12] determine seed

flow, metering accuracy, and discharge uniformity during operation. Therefore, this study was undertaken to determine the essential engineering properties of paddy seeds (RNR 15048 variety) to provide baseline data necessary for the design and development of an effective drone-based seeding mechanism for paddy cultivation.

Materials and Methods

This research was undertaken with a view to develop a drone mounted seed sowing system for paddy. With the functional components including seed metering mechanism and shooting mechanism suitable for agricultural drones to sow paddy. The engineering properties of paddy seeds which influence the development of drone mounted seed sowing system and the optimum design values for functional components like seed box, feeding mechanism, metering mechanism and shooting mechanism were determined.

Engineering properties of paddy seeds

Commonly grown paddy variety RNR (15048) variety of paddy seeds was selected for the study and collected from the Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur. Engineering. The engineering properties viz., seed size, sphericity, hundred seed weight, moisture content, bulk density, true density, angle of repose and coefficient of friction were determined for development of seed box, seed metering mechanism and seed shooting mechanism for sowing through drone. The engineering properties of paddy seeds were studied in the laboratory of Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, UAS, Raichur. Bulk density and true density values helped in design of seed box capacity. Angle of repose and coefficient of frictional property were determined to decide required slope for free flow of paddy seeds from the seed box. The procedures followed for determining engineering properties of paddy seeds are discussed below.

Size (Physical Size)

The equivalent diameter of seed is defined as seed size. The physical size of seeds helped in designing flute size length, depth and number of seeds to be required cell of seed metering wheel.

Vernier Caliper

The size of seed was analyzed in terms of length (l), width (w) and thickness (t). The dimensions of paddy seeds were measured by using digital Vernier Caliper (least count of 0.1mm) as shown in Plate 1. The sample of paddy seeds were taken and the dimensions viz., l, w and t were measured at three major axes. Each seed size in terms of equivalent diameter (D_e) was also analyzed by using following formula (Mohsenin, 1970) [9].

$$D_e = (l \times w \times t)^{\frac{1}{3}}$$

Where,

D_e = equivalent diameter of paddy seed, mm

l = length of paddy seed, mm

w = width of paddy seed, mm

t = thickness of paddy seed, mm

Sphericity

Sphericity is the indirect measurement of selected seed in terms of closeness to the sphere. It is defined as the ratio of the surface

area of a sphere with the same volume as the seed of the surface area of the seed. The sphericity property described the uniform free flow of paddy seed from the cell surface. The sphericity of the paddy was calculated by using following equation (Mohsenin, 1970) [9].

$$\Phi = \frac{(l \times w \times t)^{\frac{1}{3}}}{l}$$

Where,

Φ = Sphericity

l = Length of seed, mm

w = Width of seed, mm

t = Thickness of seed, mm



Plate 1: Measurement of size of paddy seeds using digital vernier caliper

Moisture content

The moisture content of the paddy seeds was determined by using oven dry method. Five samples of paddy seeds with known weight were placed in container and weighed on digital weighing balance. The samples after weighing were kept in the dry oven machine at 103° C for 17 hours. After 17 hours the seed samples were removed and cooled in desiccators. The dried paddy seeds were again weighed on the weighing balance. The moisture content of paddy seeds was calculated using following equations (Sahay and Singh, 1994) [12].

$$MC = \frac{W_i - W_d}{W_i} \times 100$$

Where,

MC = Moisture content (w.b.), %

W_i = Initial weight of sample, g

W_d = Dried weight of sample, g

Bulk density

The bulk density of the paddy seeds is the weight of seed per unit volume. Seed samples with known weight were placed in cylindrical beaker which was having diameter of 7.75 cm and height of 11.55 cm (Plate 2). Bulk density was calculated as the ratio of weight of seeds in the container to the volume of the container and expressed as kg m⁻³ (Garnayak *et al.* 2008) [3].



Plate 2: Measurement of bulk density of paddy seeds

True density

The true density of paddy seeds was analysed by toluene displacement method (Plate 3). The toluene was poured up to the level of 15 ml and 5 gram of paddy seed was placed into the beaker. After placing paddy seeds, increase in toluene level was noted. The increased level of toluene is equal to is the displaced volume of toluene (Sacilik *et al.* 2003).



Plate 3: Measurement of true density of paddy seeds

Thousand seed count and weight

The 1000-paddy seed weight was used to determine the number of paddy seeds required per meter area for the desired seed rate. One thousand paddy seeds were counted using Digital seed counter instrument (Plate 4) and weighed by using an electronic balance with sensitivity of 0.0001 g and expressed in g (Ghadge *et al.* 2012) [4].



Plate 4: Measurement of 1000 paddy seeds count using digital seed counter

Angle of repose

The angle of repose determines the flowability of seeds. The angle of repose was determined by placing the paddy seeds in a conical container. The conical container at a height has opening at the bottom and slowly open the opening at bottom (Palilo *et al.* 2018) [10], so that the paddy seeds fall from a certain known height on a circular disc of diameter 13 cm to facilitate formation of heap and then the height of heap form which was formed on the circular disk was noted (Bashir and Haripriya 2016) [1]. The measurement of angle of repose of paddy seeds was given in Plate 5 and following equation was used to determine angle of repose.

$$\theta = \tan^{-1}\left(\frac{h_0}{r}\right)$$

Where,

θ = Angle of repose, deg

h_0 = Height on heap, m

r = Radius of heap, m



Plate 5: Measurement of angle of repose testing equipment

Coefficient of friction

The standard apparatus of MS sheet was used to determine the coefficient of friction. The known amount of paddy seeds was filled in the wooden container attached to the one end of string placed on the MS sheet and loading plate was attached to another end of string which was hanging down the MS sheet as shown in Plate 6. The weight was added on the loading plate until the filled wooden container starts moving from its place due to the downward moment of the loading plate. The procedure was repeated for three samples. The coefficient of friction of paddy seeds was calculated by using following relationship (Mohsenin, 1970) [9].

$$\mu = \frac{F}{N}$$

Where,

μ = Coefficient of friction

F = Frictional force (force applied), g

N = Normal friction (weight of the grain), g



Plate 6: Measurement of coefficient of friction testing equipment

Results and Discussion

This chapter deals with the results obtained pertaining to various engineering properties of paddy seeds, some of the engineering properties of paddy seeds viz., size, sphericity, moisture content, true density, bulk density, weight of thousand seeds, angle of repose and coefficient of friction were determined by standard procedure. The results of the engineering properties are summarized below:

Seed size (mm)

The dimensional properties of paddy seeds were systematically measured using a vernier caliper. The average length of the paddy seeds was determined to be 7.61 mm, with minimum and maximum length measurements ranging from 6.97 mm to 8.08 mm. The mean seed width was 1.60 mm, with a range of 1.32 mm to 1.84 mm. Furthermore, the average thickness was 1.12 mm, with a minimum of 0.94 mm and a maximum of 1.23 mm. The mean equivalent diameter (D_e) of the paddy seeds was 4.58 mm (Table 1), with a range from 3.21 mm to 5.90 mm.

Sphericity

The sphericity of paddy seeds was determined using vernier caliper. The average sphericity of paddy seeds using vernier calipers was found 0.31 with standard deviation of 0.02 (Table 1). The sphericity of paddy seeds using vernier was varied between 0.27 to 0.31, In the present study, the sphericity of paddy seed obtained was found short slender shape.

Moisture content (%)

In order to achieve better planting performance and favorable germination, the moisture content of paddy seeds should be optimum. The moisture content of the selected paddy seeds, determined by the oven-dry method, varied from 9.53 to 10% (w.b.) with a mean of 9.71% (w.b.) as given in Table 1.

Bulk density (kg m⁻³)

The bulk density of the seeds is expressed as the weight of uncompacted seed mass per unit volume. The bulk density of the selected paddy seeds ranges from 506.56 to 528.59 kg m⁻³. The average bulk density of paddy seeds was 515.74 kg m⁻³ as given in Table 1.

True density (kg m⁻³)

The true density (TD) of RNR paddy was measured and recorded a mean value of 1215.38 kg/m³ (Table 1). The values ranged from 1198.63 to 1222.6 kg/m³, with a standard deviation of 10.73, indicating minimal variation among the samples.

Thousand seeds weight (g)

The 1000 seed weight of RNR paddy was measured using a digital seed counter, showed a mean value of 12.23 g (Table 1). The values ranged between 12.17 g and 12.26 g, with a very low standard deviation of 0.038 g, indicating high uniformity among the samples.

Angle of repose (deg)

Angle of repose determined the flow ability of the seeds through seed box and the seed tube. The angle of repose was varied between the range of 34.37° to 36.8°. The average angle of repose was 35.50° as given in Table 1.

Coefficient of friction

The coefficient of friction between the MS sheet material and the selected cotton seeds was determined. The average coefficient of friction was 0.55 as given in Table 1.

The results of engineering properties of paddy seeds viz., size, sphericity, moisture content, true density, bulk density, weight of thousand seeds, angle of repose and coefficient of friction, obtained are in concurrent with the results obtained and reported by Patel *et al.* (2013) ^[10], Mahilang *et al.* (2018) ^[6] and Meera *et al.* (2019) ^[8].

Table 1: Engineering properties of paddy seeds

Sl. No.	Particulars	Value
1	Equivalent diameter (De)	4.58 ± 1.09
2	Sphericity	0.31 ± 0.02
3	Moisture Content (%)	9.71 ± 0.20
4	Bulk Density (kg m ⁻³)	515.74 ± 8.99
5	True Density	1215.38 ± 10.73
6	Thousand seeds weight	12.23 ± 0.04
7	Angle of Repose	35.50 ± 1.06
8	Coefficient of Friction	0.31

Conclusion

The engineering properties of paddy seeds (RNR 15048 variety) were successfully determined to support the design and development of a drone-based seeding mechanism. The obtained parameters such as seed size, sphericity, bulk and true density, angle of repose, and coefficient of friction provides essential data for optimizing seed flow and metering system design. These findings ensure uniform seed discharge, reduced seed breakage, and efficient drone based sowing performance. Hence, the study serves as a valuable foundation for developing precision drone-based paddy seeding technology.

References

1. Bashir M, Haripriya S. Assessment of physical and structural characteristics of almond gum. *International Journal of Biological Macromolecules*. 2016;93:476-482.
2. Dahare R, Kumar T, Nishad, Sahu B. Evaluation of some physical and engineering properties of Chhattisgarh popular paddy varieties for suitability of flaked rice (poha). *International Journal of Current Microbiology and Applied Science*. 2019;8(3):1506-1513.
3. Garnayak DK, Pradhan RC, Naik SN, Bhatnagar N. Moisture-dependent physical properties of Jatropha seed (*Jatropha curcas* L.). *Industrial Crops and Products*. 2008;27:123-129.
4. Ghadge PN, Prasad K. Some of the physical properties of rice kernels variety PR-106. *Journal of Food Processing and Technology*. 2012;3:175.
5. Kumar A, Suresh K, Kuldeep D, Sandeep K, Mukesh K. Productivity and economics of direct seeded rice. *Journal of Applied and Natural Science*. 2015;7(1):410-416.
6. Mahilang KKS, Sonboier K, Jaisawal PMY, Khare N, Mahilang TT. Some physical properties of paddy seeds and fertilizer. *International Journal of Current Microbiology and Applied Science*. 2018;7:235-241.
7. Mai WX, Ablez B, Zhang B, Zeng FJ, Tian CY. Rice yield under different cultivation patterns. *Chinese Agricultural Science Bulletin*. 2019;35(36):1-5.
8. Meera M, Smita M, Haripriya S. Varietal distinctness in physical and engineering properties of paddy and brown rice from southern India. *Journal of Food Science and Technology*. 2019;56:1473-1483.
9. Mohsenin NN. *Physical properties of plant and animal materials*. New York: Gordon and Breach Science Publications; 1970.
10. Patel N, Jagan SK, Jha SK, Sinha JP, Amrender K. Physical properties of basmati varieties of paddy. *Journal of Agricultural Engineering*. 2013;50(4).
11. Palilo AAS, Majaja BA, Kichonge B. Physical and mechanical properties of selected common beans (*Phaseolus vulgaris* L.) cultivated in Tanzania. *Journal of Engineering*. 2018;1:1-9.
12. Sahay KM, Singh KK. *Unit operations of agricultural processing*. New Delhi: Vikas Publishing House Pvt Ltd; 1994.
13. Song CC, Zhou Z, Luo XW, Jiang R, Lan YB, Zhang HY. Review of agricultural materials broadcasting application on unmanned helicopter. *Journal of Agricultural Mechanization Research*. 2018;40(9):1-9.