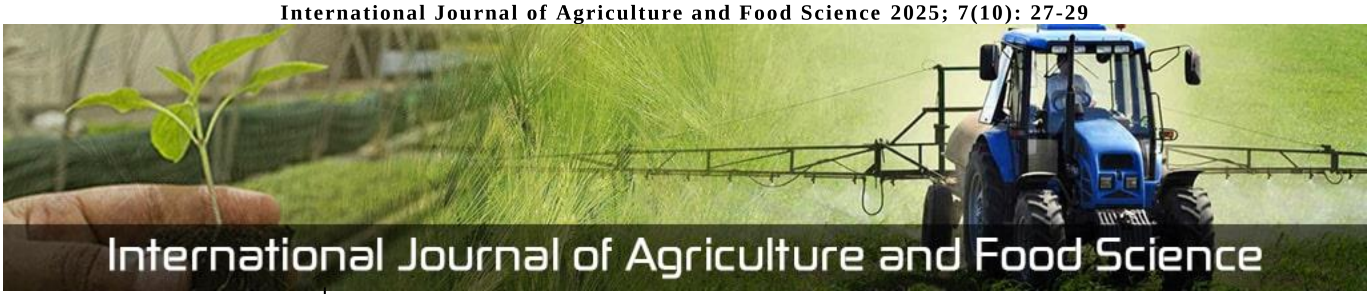
International Journal of Agriculture and Food Science 2025; 7(10): 27-29



ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(10): 27-29
www.agriculturaljournals.com
Received: 11-07-2025
Accepted: 12-08-2025

Shivasharana
M. Tech. Scholar, Dept. of Farm Machinery and Power Engineering, Dr. ASCAE & T, MPKV, Rahuri, Maharashtra, India

Dr. RK Rathod
Assistant Professor, ICAR-AICRP on FIM, Dr. ASCAE & T, MPKV, Rahuri, Maharashtra, India

Dr. TB Bastewad
Professor and Principal Investigator, ICAR-AICRP on FIM, Dr. ASCAE & T, MPKV, Rahuri, Maharashtra, India

Dr. SC Bhangare
Assistant Professor, ICAR-AICRP on FIM, Dr. ASCAE & T, MPKV, Rahuri, Maharashtra, India

Dr. MR Patil
Associate Professor, Dept. of Statistics, PGI, MPKV, Rahuri, Maharashtra, India

Corresponding Author:
Shivasharana
M. Tech. Scholar, Dept. of Farm Machinery and Power Engineering, Dr. ASCAE & T, MPKV, Rahuri, Maharashtra, India

Study of Physical Properties of Soybean (*Phule Kimaya*(*KDS-753*)) and Maize (*African Tall*) Seeds

Shivasharana, RK Rathod, TB Bastewad, SC Bhangare and MR Patil

DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i10a.851

Abstract
Study of physical properties of soybean and maize seeds was carried out for the development of a seed metering mechanism for a tractor-operated multi-crop planter. The average length, width, and thickness of soybean seeds were 8.49 mm, 6.74 mm, and 5.40 mm, respectively, while maize seeds measured 11.19 mm, 8.85 mm, and 4.58 mm. The average geometric mean diameter was 6.76 mm for soybean and 7.66 mm for maize, with sphericity of 0.80 and 0.69, respectively. Thousand seed weight averaged 360.10 g for soybean and 281.62 g for maize, and bulk densities were 720 kgm^{-3} and 680 $kg.m^{-3}$, respectively. The average angle of repose was 23.84° for soybean and 28.65° for maize, indicating better flow characteristics of soybean seeds. These properties guided the design and development of the seed metering mechanism, particularly in selecting flute size, flute exposure, and hopper outlet geometry to ensure consistent and efficient performance for both crops.

Keywords: Physical properties, angle of repose, soybean, maize, multi crop planter

Introduction
Physical properties of seeds play a vital role in the design and development of agricultural machines used for planting, processing, transporting, packaging, and storage. The effectiveness of seed metering devices largely depends on the engineering properties of seeds, such as size, shape, sphericity, bulk density, thousand seed weight, and angle of repose. Knowledge of these parameters is essential for selecting flute dimensions, hopper outlet geometry, and exposure settings to ensure smooth seed flow, minimize clogging, and reduce damage during sowing operations.

Soybean (*Glycine max L.*) is one of the most important oilseed crops cultivated worldwide, valued for its high protein and oil content. In India, soybean occupies an area of about 10.84 million hectares with an annual production of nearly 14.48 million tonnes and average productivity of 1354 $kg.ha^{-1}$ (USDA FAS, 2024-25). Major soybean-producing states include Madhya Pradesh, Maharashtra, Rajasthan, and Chhattisgarh. Variations in seed size, sphericity, and bulk density of soybean directly influence seed flow behaviour in planters, making it important to study its physical properties for efficient metering device development. Maize (*Zea mays L.*) is another significant cereal crop widely grown across India, serving as food, feed, and industrial raw material. India ranks among the top maize producers globally, with an area of about 9.5 million hectares, production of 31.65 million tonnes, and productivity of 3322 $kg.ha^{-1}$ (USDA FAS, 2024-25). In maize, seed dimensions, thousand seed weight, and surface characteristics play a crucial role in determining metering efficiency, seed spacing accuracy, and reduction of seed damage during sowing.

Thus, the study of the physical properties of soybean and maize seeds provides valuable data for the development and refinement of seed metering mechanisms in multi-crop planters. This ensures accurate seed placement, uniform crop stand, and enhanced field performance under variable operating conditions

Material and Methods
Physical Properties of Maize and Soybean Seeds
The physical properties of maize and soybean relevant to the design of the seed metering mechanism were determined. Two varieties of seeds were selected for the study: *Phule Kimaya (KDS-753)* for soybean and *African Tall* for maize.

A total of 30 samples were evaluated for properties including seed size, sphericity, bulk density, angle of repose, and thousand seed weight (TSW).

Seed Size

Randomly selected seeds were measured for three linear dimensions, i.e., length (l), width (w), and thickness (t), using a digital Vernier calliper (accuracy 0.05 mm) to calculate its geometric mean diameter by the formula (Ingale *et al*, 2016) [4].

$$\text{Size} = (l.w.t)^{1/3} \quad \dots (1)$$

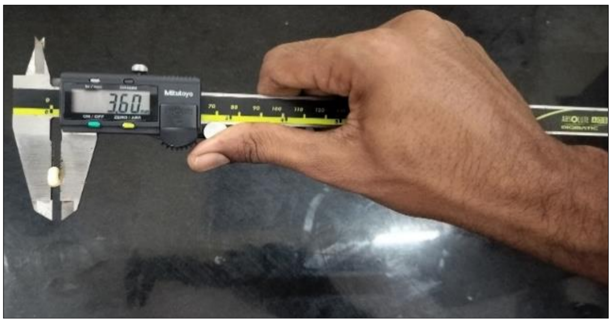


Fig 1: Seed size measurement by digital Vernier caliper

Sphericity (φ): The sphericity (ϕ) is defined as the ratio of the surface area of the sphere having the same volume as that of the grain to the surface area of the grain. Sphericity was calculated using the following relationship (Mohsenin, 1986) [7].

$$\Phi = \frac{(l.w.t)^{1/3}}{l} \quad \dots (2)$$

Where,
φ = sphericity
L = length, mm
W = width, mm
T = thickness, mm

Bulk density: Determined by filling a glass container of known volume (V) with seeds poured from a constant height and striking off excess. Bulk density was calculated as:

$$\text{Bulk density} = \left(\frac{M}{V}\right) \quad \dots (3)$$

Where,
M = Mass of the seed sample, kg
V = Volume of glass jar sampler, m^3

Angle of repose: Using the fixed-funnel method, seeds were poured to form a conical heap. The angle was calculated as:

$$\Phi = \tan^{-}\left(\frac{2h}{a}\right) \quad \dots (4)$$

Where,
Φ = angle of repose, degrees
h = height of heap, m
r = radius of heap, m

Fig 2: Measurement of angle of repose

Thousand seed weight (TSW)

A random sample of 1000 seeds was weighed using a digital balance to determine TSW, which was further used for calibration of the metering mechanism.

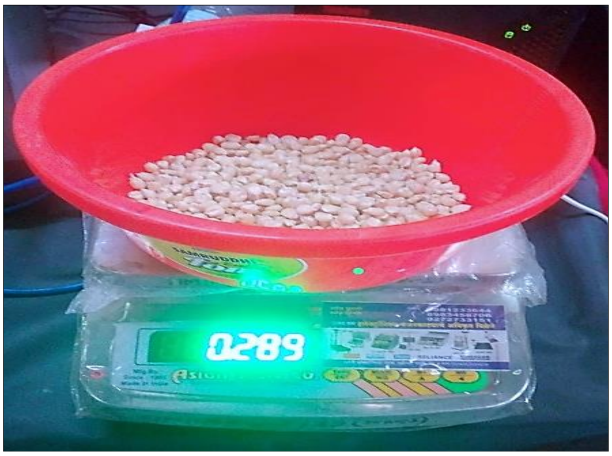


Fig 3: Measurement of Thousand seed weight

Results and Discussion

The physical properties of soybean and maize seeds were determined at 8% (d.b.) moisture content, as they play a vital role in the design of the seed metering mechanism. The varieties used for this study were *Phule Kimaya (KDS-753)* for soybean and African Tall for maize. For soybean (*Phule Kimaya (KDS-753*), the length, width, and thickness of seeds were measured as 8.49 mm, 6.74 mm, and 5.40 mm, respectively, with a geometric mean diameter of 6.76 mm and sphericity of 0.80. The thousand seed weight was 360.10 g, bulk density was 720 $kg.m^{-3}$, and the angle of repose was 23.84°. In the case of maize *(African Tall*), the length, width, and thickness of seeds were 11.19 mm, 8.85 mm, and 4.58 mm, respectively, with a geometric mean diameter of 7.66 mm and sphericity of 0.69. The thousand seed weight was 281.62 g, bulk density was 680 $kg.m^{-3}$ and the angle of repose was 28.65°. These seed properties were used to determine critical design parameters such as flute dimensions, hopper outlet size, and seed delivery angle. The sphericity and angle of repose directly affected seed flow behaviour, while the bulk density and seed weight influenced the metering force required for smooth and accurate seed discharge.

Proper consideration of these physical characteristics ensured uniform seed spacing, minimized the risk of seed damage, and reduced bridging within the hopper, thus supporting reliable performance of the seed metering mechanism under field conditions. The average measured values of these properties are presented in Table 1.

Table 1: Physical properties of soybean and maize seeds

Property	Soybean – *Phule kimaya (KDS-753)*			Maize – *African Tall*		
	Mean	SD	C.V. (%)	Mean	SD	C.V. (%)
Length, L (mm)	8.49	0.71	8.36	11.19	0.75	6.70
Width, W (mm)	6.74	0.65	9.64	8.85	1.02	11.52
Thickness, T (mm)	5.40	0.52	9.62	4.58	0.63	13.75
Geometric Mean Diameter, Dg (mm)	6.76	0.59	8.72	7.66	0.55	7.18
Sphericity, ϕ	0.80	0.03	3.75	0.69	0.05	7.24
Thousand Seed Weight (g)	360.10	2.14	0.59	281.62	1.81	0.64
Bulk Density (kg.m^{-3})	720	3.95	0.55	680	2.50	0.37
Angle of Repose (°)	23.84	0.62	0.26	28.65	0.15	0.52

Conclusion

The physical properties of soybean (*Phule Kimaya)* and maize (*African Tall*) seeds were systematically studied to support the development of a seed metering mechanism for a tractor-operated multi-crop planter. Soybean seeds exhibited higher sphericity (0.80) and a lower angle of repose (23.84°), suggesting better flow ability and reduced risk of hopper bridging compared to maize seeds, which had a sphericity of 0.69 and angle of repose of 28.65°. The geometric mean diameter, measured as 6.76 mm for soybean and 7.66 mm for maize, provided the basis for selecting flute dimensions to ensure effective handling of both crops. Bulk density values of 720 kg.m^{-3} for soybean and 680 kg.m^{-3} for maize, along with thousand seed weights of 360.10 g and 281.62 g respectively, were essential in calibrating the metering unit and achieving accurate seed delivery rates. These findings facilitated the optimization of flute exposure, hopper outlet geometry, and the power transmission system, thereby improving planter performance under variable operating conditions. Overall, the study highlighted the importance of considering seed physical properties in the development of multi-crop seed metering systems to achieve proper seed spacing, minimize seed damage, and ensure reliable field performance.

References

1. jay P, Kumar S, Sharma V. Physical properties of maize seeds and their implications for seed metering design. Agric Eng Int CIGR J. 2021;23(1):189-98.
2. Choudhary S, Jain M, Upadhyay G, Rani V, Patel B, Naresh. Engineering properties of various seeds for development of a multi crop seed metering mechanism suitable for intercropping. Inst Eng (India) Ser A. 2025;106(2):553-69.
3. Dehspande SD, Bal S, Ojha TP. Physical properties of soybean. J Agric Eng Res. 1993;56:89-98.
4. Ingale VM, More HG, Kad VP. Determination of engineering properties of aonla (*Phyllanthus emblica* L.) fruits. J Krishi Vigyan. 2016;4:12-5.
5. Jayan PR, Kumar VJF. Planter design based on physical properties of maize, red gram and cotton seeds. J Agric Eng Res. 2004;88(2):151-7.
6. Kibar H, Ozturk T. Physical and mechanical properties of soybean. Int Agrophys. 2008;22:239-44.
7. Mohsenin NN. Physical Properties of Plant and Animal Materials: Structure, Physical Characteristics, and Mechanical Properties. 2nd ed. New York: Gordon and Breach Science Publishers; 1986.
8. Sahay KM, Singh KK. Unit operations of agricultural processing. New Delhi: Vikas Publishing House Pvt. Ltd.; 1994.
9. USDA Foreign Agricultural Service (FAS). India corn area, yield and production, 2024-25. Washington, DC: USDA; 2024.
10. Yenge GB, Kad VP, Nalawade SM. Physical properties of maize (*Zea mays* L.) grain. J Krishi Vigyan. 2018;7:125-8.