Study on Physical Properties of Groundnut Cultivated in Andhra Pradesh for Design of Remote-Operated Groundnut Planter

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Physical properties of groundnut seeds play an important role in designing the cell size of seed metering device, the thickness of metering disc, the diameter of metering device and the design of seed hopper for the development of remote-operated groundnut planter. The present study describes the measurement of the physical properties of four groundnut (*Arachis hypogaea L.*)

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varieties namely K-6 (Kadiri-6), Kadiri Lepakshi, Tag-24 (Trombay Akola Groundnut-24) and Dharani using standard measuring procedures. The results obtained for four varieties revealed that the seed length, width and thickness vary from 10.29 ± 1.11 to 17.52 ± 0.76 mm, 6.15 ± 0.39 to 9.51 ± 0.46 mm and 5.48 ± 0.33 to 8.59 ± 0.47 mm, respectively. The geometric mean diameter, arithmetic mean diameter and surface area varied from 7.39 ± 0.15 to 10.58 ± 0.36 mm, 7.87 ± 0.32 to 11.13 ± 0.45 mm, and 171.98 ± 6.89 to 352.21 ± 24.54 mm^2, respectively. The Sphericity and Aspect Ratio varied from 55.51 ± 2.99 to 81.36 ± 6.87 % and 42.40 ± 4.16 to 77.82 ± 8.86 %, respectively. The Moisture Content (db.), bulk density, true density, porosity, hundred seeds weight and Angle of Repose for four different groundnut varieties are obtained as 5.25 to 10.45 %, 605.8 to 691.49 kg/m^3, 1008.12 to 1123.4 kg/m^3, 32.25 to 46.05 %, 30.485 to 45.62 g and 26.32 to 36.58^0, respectively. The maximum values of axial dimensions were considered for design of seed metering device cell. The parameters of bulk density, test weight, and angle of repose were useful in the design of the seed hopper.

1. INTRODUCTION

The groundnut (*Arachis hypogaea L.*) also known as the peanut and commonly known as poor man's nut belongs to the legume family and is a significant crop worldwide. Its origins trace back to the valleys of Paraguay, where it was first domesticated and cultivated. Groundnut is cultivated in tropics, subtropics and warm temperate conditions [1]. India holds the distinction of being the first in groundnut acreage with output of approximately 80-85 lakh MT and second largest producer globally [2]. The Indian groundnuts are available year-round, with two-crop cycle harvested in March and October, primarily under rain-fed conditions. In India, groundnuts come in various varieties, such as Runner, Java or Spanish, and red natal. Groundnut perfectly grown in well-drained Sandy loam or Sandy clay loam soil. India's top groundnut-producing states include Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Madhya Pradesh, Orissa, and Uttar Pradesh. Groundnut seeds have spaced of 30×10cm for bunch variety and 40×10cm for semi spreading & spreading varieties [3]. Groundnuts are rich source of edible oil (43-55%) and protein (25-28%). Approximately two-thirds of the world's groundnut yield is used for extraction of oil, while the remaining one-third is consumed as food [2].

The thorough knowledge on physical properties of groundnut seeds is helpful in the design and development of the hopper and seed metering mechanism of equipment for planting operation and useful for other new machinery development related for groundnut crop. The present investigation is to study some physical properties of four different groundnut varieties like K-6 (Kadiri-6), Kadiri Lepakshi, Tag-24 (Trombay Akola Groundnut-24) and Dharani which are mostly growing in the districts of Andhra Pradesh state.

2. MATERIALS AND METHODS

2.1 Preparation of Seed

The selected four different groundnut varieties K-6 (Kadiri-6), Kadiri Lepakshi, Tag-24 (Trombay Akola Groundnut-24) and Dharani were brought from Agricultural Research Station (ARS), Kadiri (Andhra Pradesh) and Regional Agricultural Research Station (RARS), Tirupati (Andhra Pradesh) to investigate Physical properties. The groundnut seeds were cleaned and graded for removing foreign materials such as dust, debris, stones, immature, broken and uneven seeds. The study of physical properties of groundnut were carried out in the laboratory of Dr. NTR College of Agricultural Engineering, Bapatla. The selected groundnut varieties can be seen in the Fig.1.

2.2 Measurement of Physical Properties of Groundnut Seeds

The physical properties determined for groundnut seeds are axial dimensions (length, width and thickness), geometric mean diameter, arithmetic mean diameter, surface area, sphericity, aspect ratio, moisture content (db.), bulk density, true density, porosity, hundred seed weight and angle of repose.

2.2.1 Axial dimensions

The axial dimensions of grain include length, width and thickness. The difference in the

dimensions can be represented in the reference seed format in Fig. 2. The axial dimensions of groundnut Seeds are measured using the digital vernier callipers (0.01mm precision). To determine the dimensions of seeds, 100 no. of seeds are selected randomly from 2 kgs sample of each variety [4]. Measurement of axial dimensions of different groundnut seeds is shown in the Fig. 3.
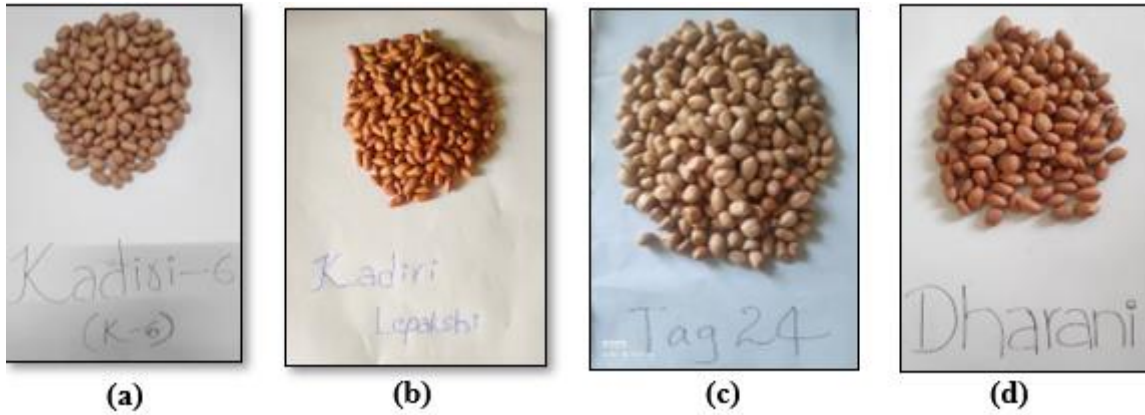

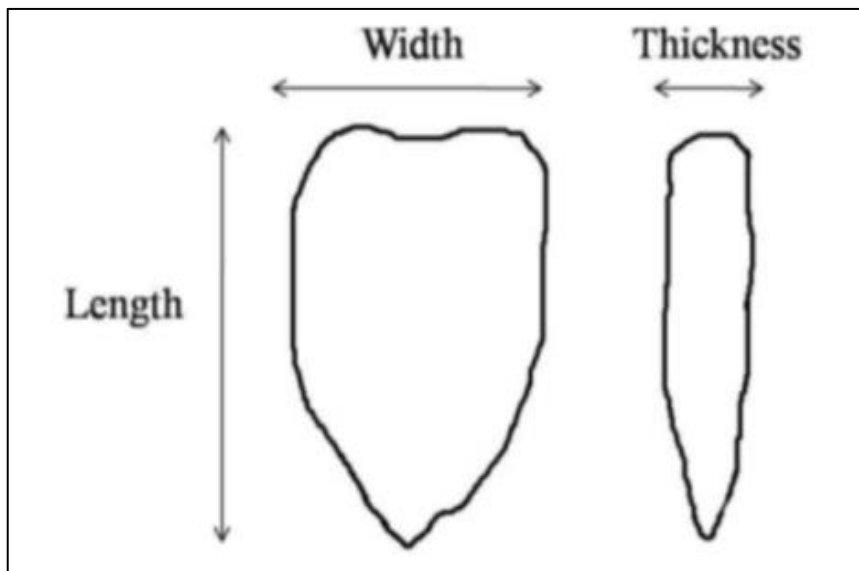**Fig. 1. Selected four groundnut varieties; (a) K-6, (b) Kadiri lepakshi, (c) Tag-24 and (d) Dharani**

Fig. 2. Representation of dimensions of reference seed

Fig. 3. Measurement of axial dimensions of groundnut seed

2.2.2 Geometric mean diameter

The geometric mean diameter of the particle is also called as the "Equivalent Diameter" [5]. The geometric mean diameter of different varieties groundnut seeds was calculated for various dimensions using the following relationship [6,7,4].

$$GMD(mm) = (LWT)^{\frac{1}{3}} \qquad \text{.... (1)}$$

Where,

L, W and T = Length, Width and Thickness of the groundnut seeds, mm

2.2.3 Arithmetic mean diameter

The arithmetic mean diameter was calculated for different groundnut varieties with various dimensions using the following relationship [6,7,4].

$$AMD(mm) = \frac{L+W+T}{3} \qquad \text{.... (2)}$$

Where,

L, W and T = Length, Width and Thickness of the groundnut seeds, mm

2.2.4 Surface area

The surface area of different groundnut seed varieties was calculated using equation [6,4] which requires geometric mean diameter value for calculation.

$$Surface\ Area, S(mm^2) = \pi \times GMD^2 \qquad \text{.... (3)}$$

Where,

GMD = Geometric Mean Diameter, mm

2.2.5 Sphericity

The Sphericity is determined by measuring the ratio between the surface area of the seed and the surface area of a sphere with the same volume as the seed and it can also define as the ratio of the geometric mean diameter to the length of the seed. The sphericity of the different groundnut seeds was calculated using the following equation given below [4]

$$Sphericity = \frac{(LWT)^{\frac{1}{3}}}{L} \qquad \text{.... (4)}$$

Where,

L, W and T = Length, Width and Thickness of the groundnut seeds, mm

2.2.6 Aspect ratio

The Aspect ratio is defined as the ratio of the width of the seed to the length of the groundnut seed. The Aspect ratio is calculated using the following relationship given below [8].

$$Aspect\ Ratio, AR = \frac{W}{L} \qquad \text{.... (5)}$$

Where,

W and L = Width and Length of the groundnut seed, mm

2.2.7 Moisture content

The moisture content of different groundnut seeds was determined using oven dry method for three replications. The moisture content on the dry basis of groundnut seeds is usually expressed in percent. The required quantity of sample weighed and kept in hot air oven at 105±2ºC for 24 hours. After drying, the dried sample was taken out and cooled in desiccator for 5-10 mins. The sample was weighed after it attaining room temperature. Samples placed inside hot air oven and measurement of moisture content can be shown in Fig. 4. The moisture content on dry basis of the groundnut seed was calculated using the below equation [4].

$$MC(db) = \frac{W_a - W_b}{W_b} \times 100 \qquad \text{.... (6)}$$

Where,

MC = Moisture Content, %
W_a = Weight of sample before drying, g
W_b = Weight of sample after drying, g

2.2.8 Bulk density (ρ_b)

The bulk Density of groundnut seeds was determined for three replications. The bulk density of seeds is the ratio of weight of sample to the known volume of container. A known volume of container was taken and seeds were filled in the container up to the top of it, excess was removed. The seeds were weighed along with container weight. The seeds weight was known by subtracting the weight of container with whole weight (weight of seed and container). Determination of bulk density was shown below in the Fig. 5. Bulk density was calculated using the below equation [8,9].

$$\rho_b = \text{(Weight of sample)/(known volume of the container)} \qquad \text{.... (7)}$$

Where,

ρ_b = Bulk Density, kg/m^3

Fig. 4. Measurement of moisture content of sample using hot air oven

Fig. 5. Measurement of bulk density

2.2.9 True density (ρ_t)

The True Density of groundnut seeds was determined by volume displacement method using toluene as the liquid. True Density is defined as the ratio of mass of the sample to the true volume of toluene displaced. To measure true density, measuring cylinder was filled with toluene to specific level and take known quantity of sample, add in measuring cylinder. The increase level of toluene in cylinder was noted. Measurement of the true Density of groundnut seeds can be shown below in the Fig. 6. The true density of different groundnut varieties has done in three replications and calculated using below equation [8,9].

$$\rho_t= \text{(weight of sample)}/\text{(true volume of toluene)} \qquad \dots (8)$$

Where,

ρ_t = True Density, kg/m^3

2.2.10 Porosity (∅)

Porosity refers to the measure of voids spaces or pores within the material. Porosity is expressed as a percentage. Porosity is calculated by the relationship between bulk density and true density by using the below equation [8,9].

$$\emptyset=1-\rho_b/\rho_t \times 100 \qquad \dots (9)$$

Where,

∅ = Porosity, %

ρ_b = Bulk Density, kg/m^3, ρ_t = True Density, kg/m^3

2.2.11 Hundred seed weight

The hundred seed weight refers to the weight of the 100 seeds using digital weighing balance having sensitivity of 0.01g in three replications [9]. The hundred seed weight is significant in design of size of hopper and helpful in knowing stability of machine during operation.

2.2.12 Angle of repose (θ)

The Angle of Repose refers as the angle between the base and the slope of the cone formed on a free vertical fall of the granular material to a horizontal plane. The angle of repose is affected by size, shape, moisture content and orientation of the seeds. The angle of repose was determined using a box with removable sliding plate. The seeds are poured in the box and then bottom slide plate is removed which allows the seeds to form a heap. The height of heap and diameter of heap is measured to calculate angle of repose using below given equation [4]. Measurement of Angle of repose is shown in Fig. 7.

$$\theta=\tan^{-1} 2(H_h) / D_h \qquad \dots (10)$$

Where,

θ = Angle of Repose
H_h = Height of heap
D_h = Diameter of heap

Fig. 6. Measurement of true density with toluene liquid

Fig. 7. Measurement of angle of repose of groundnut seeds

3. RESULTS AND DISCUSSIONS

100 seeds were selected randomly from each variety to determine some of physical properties like axial dimensions, geometric mean diameter, arithmetic mean diameter, surface area, sphericity, aspect ratio, moisture content (db.), bulk density, true density, porosity, angle of repose and hundred seed weight.

3.1 Axial Dimensions

The results shown that the three axial dimensions namely, Length, width and thickness of the groundnut varieties (K-6, Kadiri lepakshi, Tag-24 and Dharani) are represented in the tabular form of Table 1. The average values of length of K-6, Kadiri lepakshi, Tag-24 and Dharani are found to be 13.6,14.47,12.59 and 12.75mm. The average values of width of four varieties are shown as 7.79,7.40,8.51 and 7.51mm, while the thickness given as 7.22,6.63,7.73 and 6.68mm.

3.2 Geometric Mean Diameter

The Geometric Mean Diameter of four varieties are shown below the Table 2. The average values of GMD of K-6, Kadiri lepakshi, Tag-24 and Dharani are found to be 9.14, 8.92, 9.39 and 8.62mm. The highest GMD value of 11.09mm is obtained for Tag-24 variety. Whereas, the lowest value of 7.16 mm for Dharani variety.

3.3 Arithmetic Mean Diameter

The Average values of Arithmetic Mean Diameter of groundnut seeds are obtained as 9.53, 9.49,

9.61 and 8.98mm. The values of AMD of four varieties ranges from 8.07 to 11.16, 8.3 to 10.77, 7.52 to 11.86 and 7.59 to 10.72mm. The AMD values of different varieties are given below in the table 2. The AMD mean values of varies as 8.98 to 9.53mm.

3.4 Surface Area

The values of surface area of four groundnut varieties (K-6, Kadiri lepakshi, Tag-24 and Dharani) are varies as 175.06 to 363.66, 180.80 to 328.29, 171.48 to 386.98 and 161.27 to 329.89 mm^2.The Mean values of surface area of groundnut seeds are found to be 262.61, 249.86, 276.91 and 233.34 mm^2. The surface area for groundnut seeds was shown in Table 2.

3.5 Sphericity

The sphericity values of four varieties of 100 samples are obtained as 67.25, 61.66, 74.57 and 67.57 %. The sphericity values are increased from 61.66 of Kadiri lepakshi to 74.57 of Tag-24. The sphericity values are represented in the Table 3.

3.6 Aspect Ratio

The values of Aspect Ratio of Groundnut are obtained as 57.24, 51.13, 67.57 and 58.87%. The highest aspect ratio value was found as 92.54% for Tag-24 variety and the lowest value of aspect ratio can be seen for Kadiri lepakshi variety of 36.54%. The mean, maximum and minimum values of aspect ratio of each variety are shown below in the Table 3.

Table 1. Axial dimensions (mm) of four groundnut varieties

Groundnut variety	No. of Samples	Parameters	Mean Value	Maximum Value	Minimum Value
K-6	100	Length (mm)	13.60	17.48	10.79
		Width (mm)	7.79	9.68	6.14
		Thickness (mm)	7.22	8.62	5.25
Kadiri lepakshi	100	Length (mm)	14.47	17.56	11.81
		Width (mm)	7.40	8.95	5.68
		Thickness (mm)	6.63	7.94	5.64
Tag 24	100	Length (mm)	12.59	18.59	8.84
		Width (mm)	8.51	10.17	6.76
		Thickness (mm)	7.73	9.28	5.94
Dharani	100	Length (mm)	12.75	16.43	9.75
		Width (mm)	7.51	9.23	6.01
		Thickness (mm)	6.68	8.53	5.07

Table 2. GMD (mm), AMD (mm) and Surface Area (mm^2) values of different groundnut seed varieties

Groundnut Variety	GMD (mm)			AMD (mm)			Surface Area (mm^2)		
	Mean Value	Maxi. Value	Mini. Value	Mean Value	Maxi. Value	Mini. Value	Mean Value	Maxi. Value	Mini. Value
K-6	9.14	10.76	7.46	9.53	11.16	8.07	262.61	363.66	175.06
Kadiri Lepakshi	8.92	10.22	7.58	9.49	10.77	8.30	249.86	328.29	180.08
Tag 24	9.39	11.09	7.38	9.61	11.86	7.52	276.91	386.98	171.48
Dharani	8.62	10.25	7.16	8.98	10.72	7.59	233.34	329.89	161.27

Table 3. Sphericity (%) and aspect ratio (%) values of different groundnut seed varieties

Groundnut Variety	Sphericity (%)			Aspect Ratio (%)		
	Mean Value	Maxi. Value	Mini. Value	Mean value	Maxi. Value	Mini. value
K-6	67.25	79.83	55.42	57.24	75.80	41.55
Kadiri Lepakshi	61.66	75.07	50.97	51.13	68.92	36.54
Tag-24	74.57	92.9	59.32	67.57	92.54	48.19
Dharani	67.57	77.64	56.31	58.87	74.01	43.33

Table 4. Bulk density, true density and moisture content values of different groundnut varieties

Groundnut variety	Bulk Density (kg/m^3)			True density (kg/m^3)			Moisture Content (db.%)		
	Mean Value	Maxi. Value	Mini. Value	Mean value	Maxi. Value	Mini. Value	Mean Value	Maxi. Value	Mini. Value
K-6	689.19	746.95	641.31	1039.60	1077.30	974.00	6.70	6.79	6.62
Kadiri Lepakshi	622.50	664.25	612.50	1008.12	1019.20	987.25	7.55	9.38	6.60
Tag – 24	605.80	692.76	501.30	1123.40	1314.50	1000.9	10.45	10.46	10.44
Dharani	691.49	701.89	667.38	1020.66	1112.42	967.55	5.25	5.98	4.58

Table 5. Avg. hundred seed weight, Avg. porosity and Angle of repose values of different groundnut varieties

Groundnut variety	Average value of Angle of Repose (◦)	Average Hundred seeds weight (g)	Average value of porosity (%)
K-6	30.37	36.78	33.71
Kadiri Lepakshi	29.36	30.48	38.25
Tag-24	26.32	45.62	46.05
Dharani	36.58	34.72	32.25

Table 6. Average values of physical properties of four groundnut varieties

Properties	No. of Samples	Groundnut Varieties			
		K-6	Kadiri Lepakshi	Tag-24	Dharani
Length (mm)	100	13.60	14.46	12.59	12.75
Width (mm)	100	7.79	7.40	8.51	7.51
Thickness (mm)	100	7.22	6.63	7.73	6.68
Geometric Mean Diameter (mm)	100	9.14	8.92	9.39	8.62
Arithmetic Mean Diameter (mm)	100	9.53	9.49	9.61	8.98
Surface Area (mm^2)	100	262.61	249.86	276.91	233.34
Sphericity (%)	100	67.25	61.66	74.57	67.57
Aspect Ratio (%)	100	57.24	51.13	67.57	58.87
Moisture Content (db., %)	3	6.70	7.55	10.45	5.25
Bulk Density (kg/m^3)	3	689.19	622.50	605.80	691.49
True Density (kg/m^3)	3	1039.60	1008.12	1123.40	1020.66
Porosity (%)	3	33.71	38.25	46.05	32.25
Hundred seeds weight (g)	100	36.78	30.48	45.62	34.72
Angle of Repose (°)	3	30.37	29.36	26.32	36.58

3.7 Moisture Content

The mean values of moisture content of four varieties in three replications are obtained as 6.704, 7.548, 10.45 and 5.25%. the moisture content values of different varieties in three replications varies as 6.79 to 6.62%, 9.38 to 6.60%, 10.46 to 10.44% and 5.98 to 4.58%. The observed values of moisture content of four varieties are mentioned in Table 4.

3.8 Bulk Density and True Density

The Bulk Density and True Density results of four varieties are varied from 746.95 to 641.31 kg/m^3, 664.25 to 612.5 kg/m^3, 692.76 to 501.3 kg/m^3 and 701.89 to 667.38 kg/m^3. Whereas true density as 1077.30 to 974 kg/m^3, 1019.2 to 987.25 kg/m^3, 1314.5 to 1000.9 kg/m^3 and 1112.42 to 967.55 kg/m^3. The observed results of bulk density and true density of groundnut varieties were shown in below table 4. The highest value of bulk density is obtained as 691.49 kg/m^3 for Dharani variety and the lowest value as 605.8 kg/m^3 for Tag-24 variety.

3.9 Porosity

The Average porosity values results of four different groundnut varieties are obtained as shown in the Table 6. The highest value of porosity was 46.05% for Tag-24 and lowest value of porosity was 33.71% for K-6.

3.10 Hundred Seeds Weight

The average 100 seeds weight of four different groundnut varieties was presented in Table 5.

The Average hundred seeds weight varied from 45.62 for Tag-24 variety to 30.48 for Kadiri lepakshi variety.

3.11 Angle of Repose

The average values of angle of repose of four varieties were reported as given in Table 5. The highest value was reported as 36.58° for Dharani and lowest value was 26.32° for Tag-24. The angle of repose of different groundnut seeds was varied from 29.25 to 33.16°, 26.87 to 31.52°, 26.87 to 29.83° and 36.25 to 36.74°.

The overall Average values of measured properties of four different groundnut varieties (K-6, Kadiri Lepakshi, Tag-24 and Dharani) are represented in Table 6.

4. CONCLUSIONS

Physical Properties of four groundnut varieties namely K-6, Kadiri Lepakshi, Tag-24 and Dharani was determined.

- The results shown that the seed length varied from 10.29 ± 1.11 to 17.52 ± 0.76 mm, width as 6.15 ± 0.39 to 9.51 ± 0.46 mm, whereas the thickness values as are varied from 5.48 ± 0.33 to 8.59 ± 0.47 mm for four varieties. The observed GMD values was varied from 7.39 ± 0.15 to 10.58 ± 0.36 mm, AMD 7.87 ± 0.32 to 11.13 ± 0.45 mm, Surface area 171.98 ± 6.89 to 352.21 ± 24.54 mm^2, Sphericity as 55.51 ± 2.99 to 81.36 ± 6.87 % and Aspect Ratio as 42.40 ± 4.16 to 77.82 ± 8.86 % respectively.

- Similarly, the Moisture Content(db.), bulk density, true density, Porosity, hundred seeds Weight and Angle of Repose for four different groundnut varieties are obtained as 5.25 to 10.45 %, 605.80 to 691.49 kg/m^3, 1008.12 to 1123.4 kg/m^3, 32.25 to 46.05 %, 30.485 to 45.62 g and 26.32 to 36.58^o respectively.
- The values of axial dimensions, geometric mean diameter, sphericity, bulk density, true density, porosity and hundred seed weight of Tag-24 and K-6 varieties were compared with the values obtained from the literature [10]. The comparison of both papers shown that the above-mentioned properties have similar values.
- The obtained axial dimensions are helpful in selecting the seed metering device for developing groundnut planter. The maximum dimensions are considered for seed metering cell selection. The angle of repose, bulk density, hundred seeds weight and dimensions are used in the design of hopper of needed capacity and helpful in design of seed metering cell size and diameter.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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