

Determination of Physical and Engineering Properties of Fenugreek, Spinach and Radish Seeds for the Development of SMM (Seed Metering Mechanism)

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ABSTRACT

The physical characteristics of seeds must be studied in order to develop its seed metering mechanism. It was discovered that the physical characteristics of fenugreek, spinach, and radish were useful in the development of seed-metering plates. According to the findings, the length, width, and thickness of fenugreek, spinach, and radish seeds, respectively, ranged from 3.51 to 4.17 mm, 2.91 to 3.74 mm, and 1.56 to 2.36 mm; 3.54 to 4.28 mm, 3.30 to 4.12 mm, and 3.15 to 3.91 mm; and 3.92 to 4.80 mm, 2.78 to 3.59 mm, and 2.03 to 3.01 mm. Fenugreek, spinach, and radish have average diameters for sphericity and geometry that, respectively, range from 75.40 to 76.10% and 2.41 to 3.34 mm, 94.51 to 95.36% and 3.05 to 3.92 mm, and 73.61 to 74.30% and 2.51 to 3.68 mm. Fenugreek, spinach, and radish were among the crops whose bulk density and angle of repose were measured; these values were 0.760 g/cm³ and 15.10°, 0.685 g/cm³ and 16.97°, and 0.608 g/cm³ and 25.10°, respectively.

Key words: Fenugreek, Spinach, Radish, Plates, Geometry, Sphericity, Angle of repose, Bulk density etc.

Introduction

Fenugreek (*Trigonella foenum gracum*) is also known as methi, it is cool-season crop cultivated for seeds and leaves. It is native to South Eastern Europe and South Western Asia, with India being one of its natives. A pH range of 6.0 to 7.0 is considered optimum. It is a rich source of vitamins, minerals, and vitamin K. Fenugreek can be cultivated on all soil types, with the main planting seasons being June-July and October-November. Rajasthan alone produces over 80% of fenugreek, with Gujarat, Madhya Pradesh, Chhattisgarh, and Uttar Pradesh also growing.

Spinach (*Spinacia oleracea*) is likewise known as palak is a leafy green flowering plant native to cen-

tral and western Asia has a global production of 32 million tonnes in 2021, with China accounting for 92%. It is rich in nitrates and nitrites, and can be tolerant to warm weather but may cause premature bolting. Soil should be sandy loam and slightly alkaline, with a pH range of 6.0-7.5. Spinach is easy to grow, with excellent nutritional value, vitamin A and C, protein, calcium, and iron. It is an annual and cross-pollinated crop in India.

Radish, an edible root vegetable, belongs to the Brassicaceae family and is a quick-growing herb in tropical and temperate regions. It thrives on light, sandy loam soil, with ideal pH 5.5 to 6.8, temperature 18-25 °C, and rainfall 100-225 cm. Major growing states include West Bengal, Bihar, Uttar Pradesh, Karnataka, Punjab, and Assam. Radish is a rich

source of vitamin B6, calcium, copper, magnesium, riboflavin, ascorbic acid, folic acid, and potassium.

The physical characteristics details are essential to the development of the planter's metering mechanism. The data can also be employed to develop a structure for handling, processing, and preserving it. When the size, shape, and density of the seed are determined, it is simple to separate undesirable particles from the seed using oscillating chaffers. The design of mass flow structures is influenced by the angle of repose. Measurements were made of the fenugreek, spinach, and radish seeds' size, shape, bulk density and angle of repose

Materials and Methods

Generating a sample

The three crops fenugreek, spinach, and radish were selected. By passing the selected seeds through a metal screen and being manually picked, the seeds were purified of foreign objects, damaged seeds, and substances.

Determination of Physical Properties

We identified and determined the seed properties that were essential to the development of the seed metering mechanism, processing, and storage systems. Length, width, thickness (Fig. 1), geometric mean diameter, sphericity, bulk density and angle of repose of fenugreek, spinach, and radish, among other parameters, were assessed using conventional methods. The moisture content of the fenugreek, spinach and radish seeds were found to be 9.36 %, 9.53 %, and 9.50 % on dry basis. By the oven drying procedure at 105 °C was used to gauge the moisture content of the chosen seed. The moisture content of fenugreek, spinach, and radish was assessed to their physical characteristics using the following methods:

$$\text{Moisture Content (db) \%} = \times 100 \quad \dots (1)$$

Measurement of fenugreek, spinach and radish seeds

Every seed's essential characteristic is its size. The seed size is used to design the metering device's cell. The seed's length, width, and thickness were used to determine its dimensions. Vernier caliper with a minimum count of 0.01 mm were used to measure the size of the seed as shown in Fig. (1). 50 seeds were selected at random to use for the measure-

ment.

Geometric mean diameter

The following formula, which suggested by, was used to determine the size of the seeds:

$$\text{Geometric mean diameter (Dg)} = (\dots (2)$$

Where,

L = Length mm;

W = Width mm; and

T = Thickness mm.

Sphericity

Seed shape is crucial for designing metering plates, with sphericity being the ratio of cube root to seed length, determined using a formula:

$$\text{Sphericity (\%)} = \dots (3)$$

Where,

L = Length mm;

W = Width mm; and

T = Thickness mm.

Bulk density

Bulk density (BD) is the mass per unit volume, calculated by determining container volume and grain weight. Used a measuring cylinder with a diameter of 73.5 cm and height of 100 cm to calculate BD for selected seed.

$$\text{Bulk density (BD)} = \dots (4)$$

Angle of repose

The angle of repose is the angle between the base and slop of a cone formed from seed fall on a level plane. It indicates cohesion among seed flows, with higher angles indicating higher cohesion.

$$\dots (5)$$

Where,

μ = Coefficient of friction.

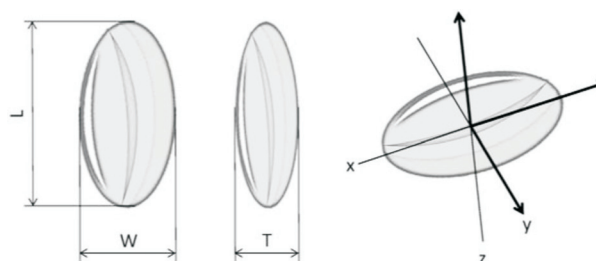


Fig. 1. Seed geometry for dimension analysis

W_1 = Force of friction.

W_2 = Force normal to the force of contact.

Measurement of fenugreek seed

Measurement of spinach seed

Measurement of radish seed

Results and Discussion

Below are the results based on the physical characteristics of fenugreek, spinach, and radish seeds:

Fenugreek, Spinach and Radish Seeds

Table 1 shows that the dimensions of selected seeds average length, width, thickness, geometry mean diameter, and sphericity values (Fenugreek at 9.36 percent moisture content were 3.84 mm, 3.38 mm, 1.93 mm, 2.89 mm and 75.72 %), (Spinach at 9.53 percent moisture content were 3.91 mm, 3.66 mm, 3.57 mm, 3.66 and 94.94 %) and (Radish at 9.50 percent moisture content were 4.36 mm, 3.21 mm, 2.38 mm, 3.17 and 73.91 %) respectively. Altunta^o *et al.* (2005), Ebaid (2005), EI-Nakib (2008), Meghwal and Goswami (2012) and Zapotoczny *et al.* (2017) were also reported similar findings. These dimensions of seeds were considered in designing the cell size of

seed metering plate for radish seed.

The average sphericity for fenugreek was calculated $75.72 \pm 4.46\%$, for spinach it was $94.98 \pm 3.87\%$ and for radish seed it was $73.91 \pm 4.16\%$. The value of sphericity was nearer to that reported by Zare *et al.* (2011) and Mollazade *et al.* (2009), this variation in sphericity might be due to crop variety. Zare *et al.* (2011) also reported that due to high difference in spatial dimensions the sphericity could be lower for fenugreek seed. The value of sphericity reported by Balasubramanian *et al.* (2012) and Coskuner and Karababa (2007) was higher than the observed, this difference in value of sphericity for spinach seed is because they have reported the sphericity of whole spinach seed while the sphericity of split spinach seeds was measured in this study.

Table 2 shows that the average bulk density, angle of repose and thousand seed weight of selected seed were measured by the analysis and found to be (Fenugreek – 0.760 g/cm³, 15.1° and 14.969 g), (Spinach – 0.685 g/cm³, 16.97° and 13.440 g) and (Radish – 0.608 g/cm³, 25.1° and 11.940 g) respectively. Singh and Goswami (1996) and Mollazade *et al.* (2009) reported similar findings for fenugreek seeds. However, their bulk density values

Table 1. Average Dimension of Selected Seeds

Selected Seed		Length, mm	Width, mm	Thickness, mm	Geometric mean diameter, mm	Sphericity, %
Fenugreek	Mean	3.84	3.38	1.93	2.89	75.72
	Std. dev. (σ)	0.21	0.19	0.18	0.21	0.18
	CV (%)	5.34	5.52	9.26	7.39	0.24
Spinach	Mean	3.91	3.66	3.57	3.66	94.98
	Std. dev. (σ)	0.18	0.22	0.21	0.19	0.21
	CV (%)	4.64	6.14	5.76	5.30	0.22
Radish	Mean	4.36	3.21	2.38	3.17	73.91
	Std. dev. (σ)	0.21	0.18	0.21	0.21	0.17
	CV (%)	4.72	5.49	8.82	6.63	0.23

Table 2. Average bulk density, Angle of repose and Thousand seed weight

Selected Seed		Bulk Density, g/cm ³	Angle of Repose (°)	Thousand seed weight (gm)
Fenugreek	Mean	0.760	15.1	14.969
	Std. dev. (σ)	0.04	0.19	0.145
	CV (%)	5.26	1.29	0.970
Spinach	Mean	0.685	16.97	13.440
	Std. dev. (σ)	0.06	0.19	0.217
	CV (%)	9.05	1.10	1.617
Radish	Mean	0.608	25.1	11.940
	Std. dev. (σ)	0.05	0.19	0.11
	CV (%)	8.22	0.75	0.91

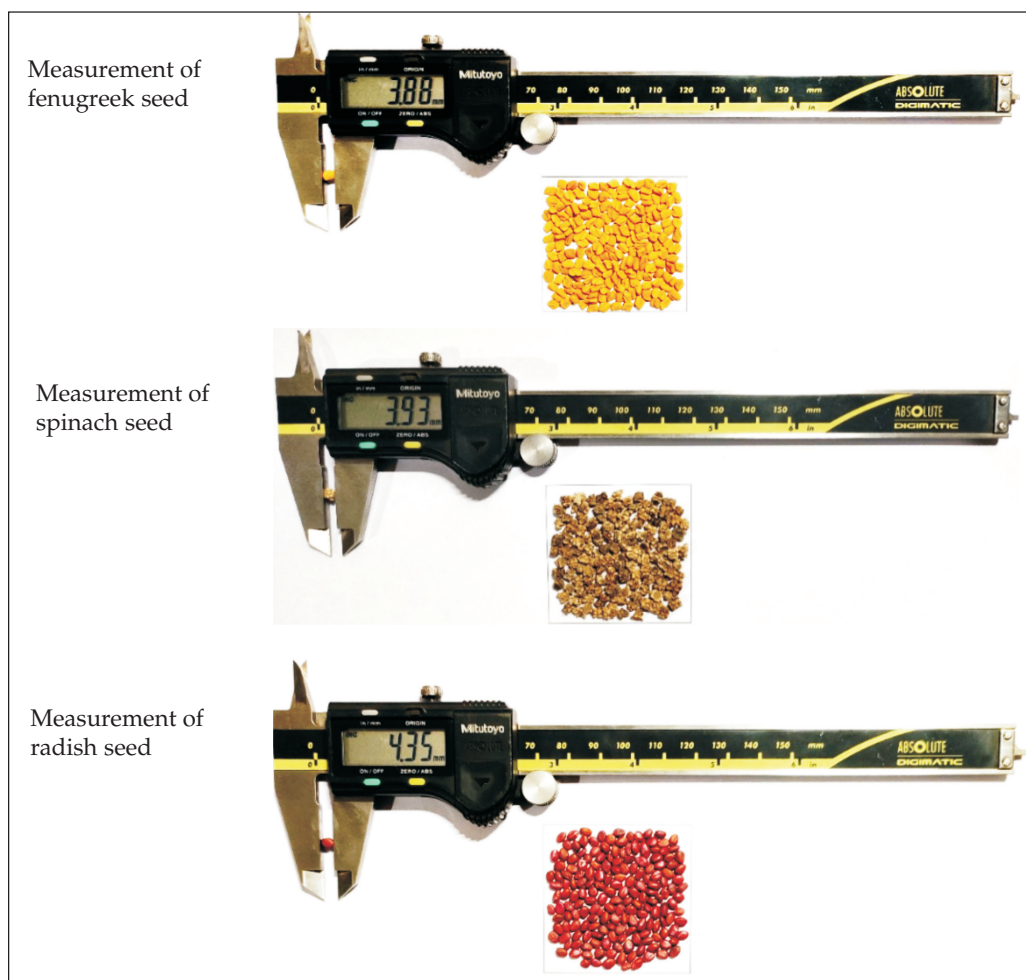


Fig. 2. Measurement of seed size (length, width and thickness)

were lower than observed for spinach seeds, as measured in split seeds. These findings were used for seed box design and seed rate calculation.

Conclusion

The physical and engineering properties were determined for the fenugreek, spinach and radish seeds at moisture content varies from 8-10% for fenugreek, spinach and radish respectively. These properties were then used to design a metering mechanism for the planting of the fenugreek, spinach and radish. The metering plate was designed and fabricated where, the cell size was determined based on dimensions i.e. length, width, thickness, geometric mean diameter, and sphericity of fenugreek, spinach and radish seeds.

In order to obtain precise seed placement, a hori-

zontal plate metering mechanism for the planting of fenugreek, spinach, and radish was selected for laboratory testing. At CAE, JNKVV Jabalpur, the seed metering mechanism's performance was assessed using an electronic experimental test rig. Seed spacing, missing index, multiple index, and quality of feed index were the performance evaluation parameters at the three forward speeds (1.2 and 3 km/h), along with the three seed dropping heights (2.5 and 7 cm). Based on the findings, the advancing speed and seed-dropping height were optimized to assure 2-3 seeds every hill.

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