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MOISTURE DEPENDANT PHYSICAL PROPERTIES OF BENGAL GRAM SEEDS (*Cicer arientimum* L.)

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Abstract: Physical properties of bengal gram seeds were evaluated as a function of moisture content. The average length, width, thickness, geometric mean diameter, thousand grain mass was 9.536 mm, 6.785 mm, 7.29 mm, 0.8090 mm, 287.89 g, respectively at moisture content of 6.15% d.b. The study showed that as moisture content increased from 6.15 to 25.27% d. b., bulk and true density decreased from 714.86 to 593.9 kg m^{-3} and from 1415 to 1350 kg m^{-3}, respectively. With increasing moisture content, porosity and angle of repose increased from 49.477 to 56.04% and from 22.15^o to 35.00^o, respectively.
Keywords: Bengal gram seeds, physical properties, moisture content.

INTRODUCTION

Bengal gram (*Cicer arientimum* L.) also known as ‘chickpea’ or ‘chana’ is a member of leguminous family. It is a major pulse crop in the Indian subcontinent and several other countries. Known for rich protein content, bengal gram is used as an edible seed as well as for making flour. The immature gram seeds are used for making vegetables and other preparations. This crop is broadly divided into two categories viz. *Kabuli* and *Des*i according to the colour, seed size and taste.

India is the leading producer and consumer of bengal gram in the world. Normally it accounts for around 40% of India’s total pulses crop production of 12-15 million tons. Major producing states are Madhya Pradesh, Uttar Pradesh, Rajasthan and Maharashtra. The production of bengal gram in the year 2010-11 was 8.25 million tons from an area of 9.51 million hectares. Its production has increased by 36 % between 2004 and 2011 with 25 % expansion in acreage and 9 % improvement in yield. In Rajasthan, Bengal gram is cultivated as a rainfed crop in most of the districts therefore, production fluctuates year to year. [21] The physical properties of the chick pea seeds in the moisture content range from 5-16 %, by making the sample through wetting the dried seeds [13].

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The objective of this study was to investigate some physical properties such as moisture content, linear dimensions, unit mass and volume, sphericity, density, porosity, angle of repose of the bengal gram seeds depending upon moisture content.

MATERIAL AND METHODS

Dry Bengal gram seeds were collected from local market for all the experiment in this study. Seeds were cleaned manually to remove foreign matter such as dust dirt stones and shaff as well as broken seeds. The initial moisture content was determined by using the hot air oven method [17]. The sample was kept at 100^0C for 16-18 hr in an oven and final weight was noted.

The samples of desired moisture content were prepared by adding the amount of distilled water as calculated from the following relation [18, 20].

$$Q = \frac{W_i(M_f - M_i)}{(100 - M_f)} \quad (1)$$

Where,

Q = mass of water to be added during rewetting, kg

W_i = initial mass of the sample of to be rewetted, kg

M_i = initial moisture content of the sample, % w.b.

M_f =final moisture content of the seed sample, % w.b.

The samples were then poured into separate poluethylene bags and the bags sealed tightly. The samples kept at refrigerator for a week to enable moisture to distribute uniformly throughout the sample. Before starting a test the required quantity of the seed was allowed to warm up to room temperature [1, 3]. All the physical properties of the seeds were assessed at moisture levels of 6.15%, 10%, 12.5%, 21.78% and 25.27% d.b. with ten replications at each moisture content. The moisture content of Bengal gram seed should be in the range from 10% to 16% for long storage period. To determine the average size of the grain, a sample of 100 randomly selected seeds and their three principal dimensions were measured using a vernier caliper to an accuracy of 0.02 mm [16]. The geometric mean diameter Dm of the grain was calculated by using the following relationship:

$$D_m = (LBT)^{\frac{1}{3}} \quad (2)$$

Where,

L= length of the seed, mm

W= width of the seed, mm

T= thickness of the seed, mm

The degree of sphericity (ф) was calculated by following relationship [15]:

$$\phi = \frac{(LBT)^{\frac{1}{3}}}{L} \quad (3)$$

Thousand seeds mass was determined with the standard method [7].

The bulk density (Pb) of grain based on the volume occupied by the bulk sample was measured using a standard hectoliter [6]. The true density (Pt) defined as the ratio between the mass of Bengal gram seeds and true volume of seed was determined using the toluene displacement method [. Porosity (∈) of the bulk is the ratio of volume of internal pores within the seeds to its bulk volume and was determined as follows [16].

$$\in = 100\left(1 - \left(\frac{Pb}{Pt}\right)\right) \quad (4)$$

The angle of repose (α) is the angle with the horizontal at which the material will rest in a pile. This was determined by using an open–ended cylinder of 15 cm diameter (d) and 50 cm height (H). The cylinder was placed at the centre of a circular plate having a diameter of 70 cm and was filled with bengal gram seeds. The cylinder was raised slowly until it formed a cone on the circular plate. The height of the cone was recorded by using a moveable pointer fixed on a stand having a scale of 0.1 cm precision. The angle of repose was calculated using the formula [5, 9, 10, 18]:

$$\alpha = tan^{-1}\left(\frac{2H}{d}\right) \quad (5)$$

RESULTS AND DISCUSSION

Seed dimensions and size distribution: The mean dimensions of 100 random seeds measured at moisture content of 6.15% d. b. The average length, width, thickness, geometric means diameter was 9.536 mm, 6.785 mm, 7.29 mm, and 0.8090 mm respectively.

Mass of thousand grains: The mass of bengal gram seeds increases linearly from 242.36 to 342 g, as shown in the Fig. 1. This may be attributed to increase in overall dimensions & size of seeds with increase in the moisture content of seeds. The effect of increment in size of seeds is more prominent in comparison to corresponding reduction in moisture content. The mass of 1000 bengal gram seeds (W_t) depicted a linear increase with moisture content and bears the following relationship with a regression coefficient (R^2) 0.971:

$$W_t = 19.86\ M + 218.3\ (R^2 = 0.991) \quad (6)$$

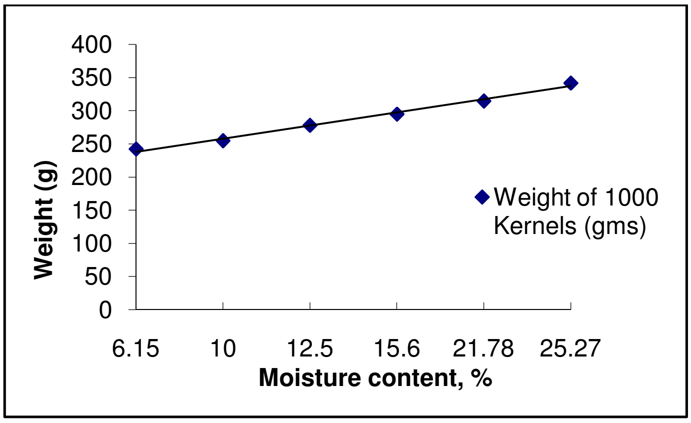

Fig. 1: Effect of maturity on thousand seeds weight

Sphericity: The sphericity of Bengal gram seed increased from 63.64% to 82.41% with increase in moisture content as shown in the Fig. 1. Some researchers reported that the value for sphericity of chick pea as 83.2 %. [13, 14]. A linear relationship exist between sphericity and moisture content and expressed by the following equation sphericity:

$$\phi = 3.719M + 60.84 \ (R^2 = 0.990) \qquad (7)$$

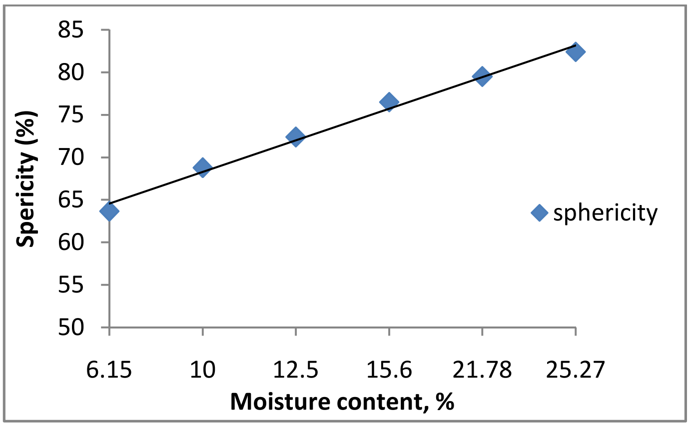

Fig. 2: Effect moisture content on sphericity of bengal gram seeds

Bulk density: Bulk density of seed at different moisture levels varied from 714.86 to 593.90 kgm^{-3} (Fig. 3 and indicated a decrease in bulk density with an increase in moisture content. The negative linear relationship of bulk density with moisture content was also observed for pigeon pea [19], by for soya bean [3] The statistical analysis of experimental data showed that the relationship between bulk density and moisture content was significant. The bulk density of seeds can be mathematically represented as

$$Pb = -25.12M + 749.3 \ (R^2=0.973) \qquad (8)$$

The kernel density at different moisture levels varied from 1415 to 1350 kgm^{-3} (Fig. 3). The effect of moisture content on kernel density of Bengal gram seed showed a decrease with increasing moisture content.

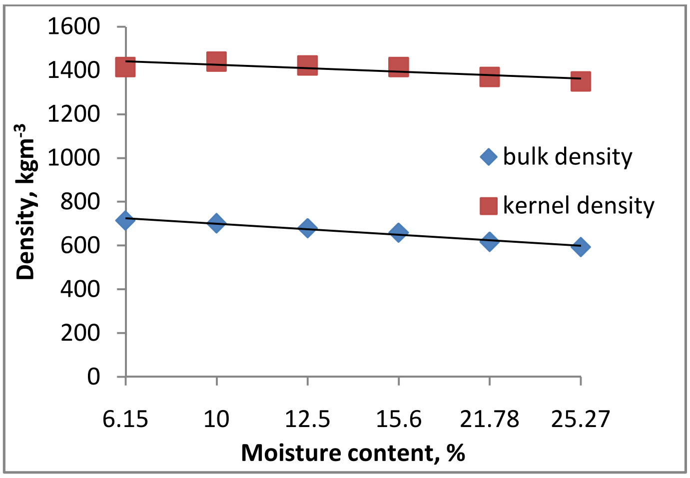

Fig. 3: Effect of moisture content on Bulk density and kernel density

Kernel density: The linear decrease in kernel density with increase in grain moisture in the range 8.7–25% d.b. for JS-7244 soya bean [3] and for chick pea [13]. The kernel density of seeds was found to bear the following relationship with moisture content

$$Pt = -15.51M + 1456 \ (R^2=0.707) \qquad (9)$$

Porosity: Since the porosity depends on the bulk as well as true or kernel densities, the magnitude of variation in porosity depends on these factors only. The porosity of Bengal gram seed increased with increase in moisture content from 6.15 to 25.27 % d.b. as shown in Fig. 5. The trend observed in Bengal gram is similar to that of chick pea [13] and pigeon pea [19]. The relationship between porosity and the moisture content of the seeds was linear;

$$\epsilon = 1.282M + 48.38 \ (R^2=0.995) \qquad (10)$$

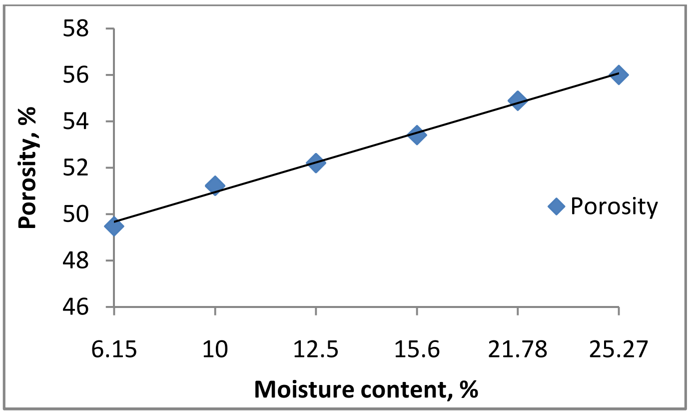

Fig.4: Effect of moisture content on Porosity

Angle of repose: The angle of repose for Bengal gram at various moisture levels are presented in Fig. 5. The angle of repose increased from 22.15 to 35^0 in the moisture range of 6.15-25.27 % d.b. The value of angle of repose for Bengal gram seed was considerably less than those reported for pumpkin, pigeon pea and fababean seed [5, 19]. This is due to the higher sphericity of chick pea seeds allowing themto slide and roll on each other. The values of the angle of repose α for bengal gram bear the following relationship with moisture content;

$$\alpha=2.522\ M + 19.98\ (R^2=0.993) \quad (11)$$

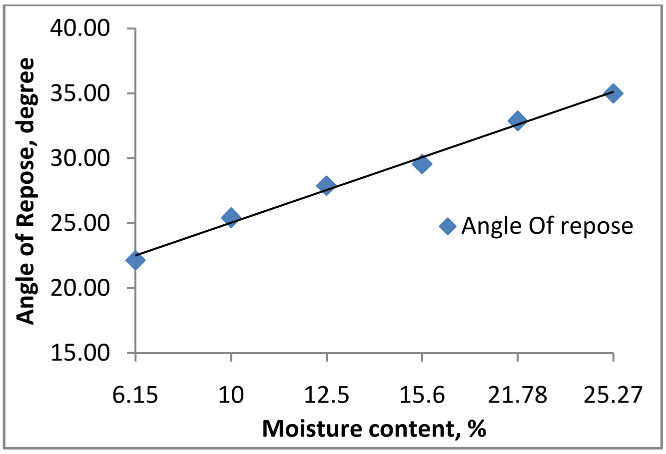

Fig. 5: Effect of moisture content on Angle of Repose

CONCLUSIONS

The average length, width, thickness, geometric mean diameter, thousand grain mass was 9.536 mm, 6.785 mm, 7.29 mm, 0.8090 mm, 287.89 g, respectively at moisture content of 6.15% d. b. The bulk density and kernel density decreased from 714.86 to 593.9 kg m^{-3} and from 1415 to 1350 kg m^{-3}, respectively as the moisture content increases from 6.15 to 25.27% d. b. With increasing moisture content, porosity increased from 49.477 to 56.004% as the moisture content increases from 6.15 to 25.27% d. b. With increasing moisture content, angle of repose increased from 22.15 to 35.00^0, respectively as the moisture content increases from 6.15 to 25.27% d. b.

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