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Determination of physical and mechanical properties of onion (Gujarat white onion-1) seeds

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Abstract
Seed size and its uniformity are very important factors considered in design and development of any type of seed planter. The physical and mechanical properties like sphericity, thousand seed weight, bulk density, true density, angle of repose and coefficient of static friction of onion seed relevant to design of metering mechanism of a planter were determined. The average length, width and thickness were 2.85, 2.11 and 1.63 mm, respectively. The mean geometric mean diameter, sphericity and roundness of onion seed were 2.132 mm, 0.75 and 0.70, respectively. The bulk density varied from 0.636 to 0.642 g cm^{-3} and true density varied from 0.163 to 1.215 g cm^{-3}. The mean porosity of onion seed was 46.22 per cent. The thousand seed weight of seed ranged from 3.502 to 3.664 g. The angle of repose varied from 37.23 to 40.69 degrees. The coefficient of static friction was determined on four different materials namely, aluminium (0.36-0.40), MS sheet (0.53-0.57), GI sheet (0.32-0.36) and SS sheet (0.28-0.32).

Keywords: Onion seed, physical and mechanical properties, sphericity, coefficient of static friction

1. Introduction

India is the second largest producer of onion in the world after China. In past 20 years, production of onion in India has increased more than four times. In 2015-16, onion crop occupied 13.20 lakh ha area with total production of 209.31 lakh tones (Indian Horticulture Database, 2016) [1]. Maharashtra, Karnataka, Madhya Pradesh, Bihar, Gujarat, Rajasthan, Haryana, Andhra Pradesh, Uttar Pradesh and Odisha are the major onion producing states. However, the productivity has not increased at that pace. Although second in onion production after China at world level, India is far behind in productivity compared to many countries. The average productivity of onion in India in the past decade stood at only 13.78 t/ha, which is lower than world average of 18.75 t/ha (Anon., 2015) [2]. The highest productivity of onion has been reported to be 67.33 t/ha in Ireland.

Generally, the onion seeds are sown in nursery and transplanted with row to row spacing of 15 cm and plant to plant spacing of 7.5 cm to get optimum yield. During onion cultivation, transplanting of seedlings, weeding and harvesting are the most labour intensive operations that are presently done manually in India. The labour requirement in manual transplanting of vegetable seedlings is also as high as253 man-h.ha-1 (Satpathy, 2003) [3]. Because of high requirement and shortage of labour, the area under onion cultivation is low and can be increased by mechanization of this crop.

Onion can also be grown by direct seeding. High precision planters place one seed at a time at a desired space along the row. In these planters, metering device has an important effect on planter performance. Metering device should hold a seed in the cell and drop it on the seed bed at the desired space. The seeds of onion are of very small size, having low density and irregular shape which poses problem in precision planting. Hence, there is a need to design and develop precision planters for small and irregular shaped seeds like onion and other vegetable crops. One of the requirements for accurate seeding by a precision planter is that the seeds be of uniform size and shape and of such a nature that they can readily be singled and handled by cell-type devices.

The physical and mechanical properties of seeds like size, shape, mass, bulk density, true density, porosity and static coefficient of friction against various surfaces play a major role while designing of a precision planter and influence in development of processing machines like seed cleaners, graders, sorting machines, transportation components in the processing plant and oil expelling machinery.

The objective of this study was to investigate some physical properties of onion seeds namely, linear dimensions, sphericity, thousand seed mass, bulk density, true density, porosity, angle of repose and static coefficient of friction against different materials.

Jayan and Kumar (2004) [4]. evaluated the physical properties namely, length, breadth, surface area, roundness, equivalent diameter, sphericity, seed weight, true density, angle of repose and coefficient of restitution of maize, red gram and cotton seeds as design parameters for a planter. Thickness and cell diameters of theseed metering discs were designed in reference to the maximum breadth andlength of seeds. Chhina and Sharma (2011) [5]. studied the physical properties for three cultivars of onion i.e. Punjab Naroya (PN), Agrifound dark red (ADR) and Agrifound light red (ALR) and compared it with pelleted seeds. Pandiselvam *et al.* (2013) [6]. identified, determined and reported some of the frictional, mechanical and aerodynamic properties of onion seeds needed for design of onion umbels thresher. Vasuki and Tajuddin (2015) [7]. designed metering mechanism and other components of a prototype inclined plate planter based on the engineering properties of cotton seeds *viz*., size, sphericity, thousand seed mass, bulk density, angle of repose, coefficient of friction and true density. Gautam *et al.* (2016) [8]. studied the physical properties of pelleted onion seeds and compared it to un-pelleted seeds.

2. Materials and Methods

For this study, raw onion seed of variety Gujarat White Onion–1 (GWO-1) was selected. One kg of seed was procured from Vegetable Research Station, Junagadh Agricultural University, Junagadh, (Gujarat). The evaluation of physical properties of onion seed was carried out in Department of Processing and Food Engineering, Junagadh Agricultural University, Junagadh.

2.1 Measurement of physical properties

2.1.1 Size

The physical properties of seeds are very essential in many aspects associated with the designing or development of a precision planter. To determine the average size of seed, 100 seeds were randomly picked and for each seed, three principal dimensions, namely length (L), width (W) and thickness (T) were measured using a vernier caliper (least count 0.01 mm).

2.1.2 Shape

The sphericity is a measure of shape character and is an indirect measure of how much a selected seed is close to a sphere. The sphericity was calculated from the measured seed linear dimensions by using following relationship (Mohsenin, 1970) [9].

$$\varphi = \frac{(l \cdot w \cdot t)^{1/3}}{l} \quad .....(2.1)$$

Where,

φ = Sphericity of seed

l = Length of seed, mm

w = Width of seed, mm and

t = Thickness of seed, mm

Shape index (SI) was calculated as follows (Ozkan and Koyuncu, 2005) [10].

$$SI = \frac{2l}{w} + t \quad .....(2.2)$$

Where,

SI < 1.25 indicates a spherical shape, and

SI > 1.25 indicates a oval shape

Elongation (E) was calculated for three orientations as follows (Durmus *et al.*, 2010) [11].

$$E = \frac{\text{Major axis length}}{\text{Minor axis length}} \quad .....(2.3)$$

Elongation at width orientation (E_w);

$$E_w = \frac{l}{w} \quad .....(2.4)$$

Elongation at thickness orientation (E_t);

$$E_t = \frac{l}{t} \quad .....(2.5)$$

Elongation at thickness orientation (E_v);

$$E_v = \frac{w}{t} \quad .....(2.6)$$

The shape of the seed was assumed on the basis of classification of common bean cultivars by Sehrali (1988) [12]. ellipticus (ellipsoid and l/w=1.51-1.71), oblongus (Long cylindroid, kidney shaped and l/w=1.85-2.31), subcompressus (subcompressed, long and (w/t)*l=1.29-2.08), and compressus (More compressed, broad and (w/t)*l =2.17-3.51).

2.1.3 Thousand seed weight

The one thousand seed mass was determined by measuring the weight of five random samples of thousand seeds by a digital balance, with an accuracy of ± 0.001 g.

2.1.4 Bulk density, true density and porosity

Bulk density is the weight of the material including the inter granular air space in unit volume. The average bulk density of onion seed was determined using the standard test weight procedure by allowing the seeds to fall into a 500 ml container from a height of 15 cm at a standard flow rate and leveling the heap above the container with zigzag strokes of the blunt ruler.

The average true density was determined using the toluene displacement method. The volume of toluene displaced was found by immersing a weighed quantity of onion seed in the toluene.

Porosity is the proportion of empty space in a mass or bulk of grain. The percentage porosity was calculated from the following relationship.

$$\varepsilon = \left(1 - \frac{\rho_b}{\rho_t}\right) \text{ x } 100 \quad .....(2.7)$$

Where,

ε = porosity

ρ_t = true density

ρ_b = bulk density

2.2 Measurement of mechanical properties

2.2.1 Angle of repose

The dynamic angle of repose was determined by using the apparatus described by Mohsenin, (1970) [9]. The seeds were filled into the box having circular platform, surrounded by a metal funnel leading to discharge hole. The seeds were allowed to escape from the box leaving a free standing cone of seeds on the platform. The angle of repose (θ) was determined from the height (h) and diameter (D) of the naturally formed heap of seed on the circular plate. The angle of repose was calculated from the following relationship.

$$\theta = \tan^{-1}\frac{2h}{D} \quad .....(2.8)$$

2.2.2 Coefficient of static friction
The coefficient of static friction for onion seed was measured against four metallic surfaces i.e. mild steel, galvanized iron, stainless steel and aluminium, respectively. A topless and bottomless transparent acrylic box of dimensions 80 mm x 80 mm x 75 mm was placed on an adjustable tilting plate, faced with the surface, and filled with the seed sample. The container was raised about 2 mm above the base of the bulk seed so as not to touch the surface. The structural surface with the container resting on it was gradually raised with a screw device until the container along with the sample just started to slide down and the angle of tilt($\emptyset$) was readfrom a graduated scale. The coefficient of static friction (μ) was calculated from the following relationship.

$$\mu = \tan\emptyset \quad ....(2.9)$$

3. Results and Discussion
3.1 Physical properties
3.1.1 Size
The values of mean and standard deviation of linear dimensions of onion seeds were measured experimentally and summarized in Table 1. The average length, width and thickness of onion seeds were found to be 2.85, 2.11 and 1.63 mm, respectively. These axial dimensions are important in determining aperture or cell sizes in seed pickup roller or plate of planter, particularly in separation of materials and other parameters in agricultural machine designs.

Table 1: Physical and mechanical properties of onion seeds

Physical / Mechanical parameters		Minimum	Maximum	Mean	Standard Deviation
Length (*l*), mm		1.83	3.65	2.85	0.340
Width (*w*), mm		1.66	2.58	2.11	0.216
Thickness (*t*), mm		1.24	2.26	1.63	0.162
Geometric Mean Diameter, mm		1.67	2.59	2.132	0.172
Sphericity		0.66	0.91	0.75	0.057
Roundness		0.58	0.90	0.70	0.067
l/*w*		1.03	1.74	1.357	0.147
w/*t***l*		2.0	5.40	3.744	0.73
Shape Index		3.30	5.17	4.341	0.341
1000 seed weight, g		3.502	3.664	3.581	0.061
Bulk density, g cm^{-3}		0.636	0.642	0.639	0.002
True density, g cm^{-3}		0.163	1.215	1.187	0.026
Porosity, per cent		45.94	46.49	46.22	0.223
Angle of repose, degrees		37.23	40.69	39.34	0.937
Coefficient of static friction	Aluminum	0.36	0.40	0.38	0.01
	MS Sheet	0.53	0.57	0.55	0.02
	GI Sheet	0.32	0.36	0.34	0.02
	SS Sheet	0.28	0.32	0.30	0.02

3.1.2 Shape
The shape of seed, in terms of sphericity, shape index and elongation is already mentioned in Table 1. The geometric mean diameter, sphericity and roundness were calculated from principal dimensions and found to be 2.13, 0.75 and 0.70 for onion seeds, respectively. The shape of the onion seeds was analyzed on the basis of values obtained for sphericity, shape index, *l*/*w* and *w*/*t***l*. The values were calculated from the principal dimensions and found to be 0.75, 4.34, 1.35 and 3.74, respectively. The average sphericity value (0.75) of onion seeds analyzed in the present study suggests that, the seeds are of hemispherical shape. The average roundness value of onion seed was found 0.70.

3.1.3 Thousand seed weight
The seed weight affects seed flow from seed metering device to the furrow opener and also influences the design of seed hopper. Hence, the thousand seed weight of onion seeds was determined. The thousand seed weight of onion seeds ranged from 3.50 to 3.66 g with a mean value of 3.58 g.

3.1.4 Bulk density, true density and porosity
The average true density and bulk density values were found to be 1.18 and 0.63 g cm^{-3}. The true density and bulk density values of the onion seed in the present study were closer to the values reported by Sunitha *et al.*, (2016) [13]. The estimated porosity value of onion seed was found to be 46.22.

3.2 Mechanical properties
3.2.1 Angle of repose and coefficient of static friction
The average value of angle of repose was found to be 39.34°. The coefficient of static friction for the onion seeds against four material surfaces i.e. MS sheet, GI sheet, Aluminium sheet and SS sheet are given in Table 1. As seen from the table, the maximum (0.55) coefficient of static friction was observed for MS steel sheet, whereas minimum (0.30) coefficient of static friction was observed for stainless sheet. MS sheet offered maximum friction followed by Aluminum sheet, GI sheet and SS sheet.

4. Conclusion
The average length, width and thickness were 2.85, 2.11 and 1.63 mm, respectively. The mean geometric mean diameter, sphericity and roundness of onion seed were 2.132 mm, 0.75 and 0.70, respectively. The mean values of bulk density, true density and porosity were 0.639 g cm^{-3}, 1.187 g cm^{-3} and 46.22 per cent, respectively. The thousand seed weight of seed ranged from 3.502 to 3.664 g. The mean value of angle of repose was 39.34 degrees. The coefficient of static friction was determined on four different materials namely, aluminium (0.36-0.40), MS sheet (0.53-0.57), GI sheet (0.32-0.36) and SS sheet (0.28-0.32).

5. References

1. Indian Horticulture Database. National Horticulture Board, Ministry of Agriculture, Government of India, New Delhi, India, 2016.
2. Anonymous. Vision 2050. ICAR - Directorate of onion and garlic research, Rajgurunagar, Pune, Maharashtra, India, 2015.
3. Satpathy SK. Effect of selected parameters on the performance of a vegetable transplanter for different crops. Unpublished M. Tech Thesis, Punjab Agricultural University, Ludhiana, India, 2003.
4. Jayan PR, Kumar VJF. Planter design in relation to the physical properties of seeds. Journal of tropical agriculture. 2004; 42(1-2):69-71.
5. Chhina RS, Sharma AD. Studies on physical properties of onion seeds (*Allium cepa* L.), Progressive agriculture. 2011; 43(1):76-80.

6. Pandiselvam R, Kailappan R, Pragalyaashree MM, Daniel Smith. Frictional, mechanical and aerodynamic properties of onion seeds. International journal of engineering research & technology. 2013; 2(10):2647-2657.
7. Vasuki G, Tajuddin A. A study on physical properties of cotton seeds for developing a high density cotton planter. International journal of agricultural science and research. 2015; 5(4):49-52.
8. Gautam A, Khurana R, Manes GS, Dixit A, Verma A. Development and evaluation of inclined plate metering mechanism for onion pelleted seeds. Biosystems Engineering. 2016; 94(4):535-543.
9. Mohsenin NN. Physical Properties of Plant and Animal Materials. New York: Gordon and Breach Science Publishers, New York, 1970.
10. Ozkan G, Koyuncu MA. Phyaical and chemical composition of some walnut (*Juglans regia* L.) genotypes grown in Turkey. Grasas y Aceites. 2005; 56(2):141-146.
11. Durmus EF, Sarka E, Bubnik Z, Schejbal J, Kadlec P. Size properties of legume seeds of different varieties using image analysis. Journal of Food Engineering. 2010; 99(4):445-451.
12. Sehrali S. Grain Legume Crops. Ankara University, Faculty of agricultural engineering, Ankara, Turkey. 1988; 1089(314):435.
13. Sunitha B, Sujatha B, Girish B, Rajkiran B, Ramana MV. Determination of physical properties of onion (Arka kirthiman). Internat. J. Proc. & post harvest technol. 2016; 7(1):36-41.