EFFECT OF *RHIZOBIUM* COATING ON PHYSICAL AND ENGINEERING PROPERTIES OF CHICKPEA SEED

Abstract:

The *Rhizobium* bio fertilizer coating may influence on the physical and engineering properties of chickpea seed. The metering mechanism, hopper design and hose pipes of seed drill was designed based up on the physical and engineering properties of *Rhizobium* coated seeds. The study was conducted to determine the physical and engineering properties viz., length, breadth, thickness, geometric mean diameter, sphericity, seed weight, bulk density, angle of repose and coefficient of static friction of uncoated, and bio-fertilizer coated chickpea seeds for design of Aqu-ferti seed drill. The hopper of seed drill was designed based up on the angle of repose and coefficient of static friction of biofertilizer coated chickpea seeds. The physical properties of chickpea seeds plays very important role in design of hopper, hose pipe and metering mechanism of seed drill The physical properties viz., Length, breadth and thickness of the uncoated and bio-fertilizer coated chickpea seeds were 9.01±0.62 mm, 7.059±0.69 mm, 6.57±0.54 mm and 9.06±0.44 mm, 7.144±0.90 mm, 6.9±0.22 mm, respectively. Roundness and sphericity of uncoated and bio-fertilizers coated chickpea seeds were 87.23 ±2.13%, 87.36±2.72% and 81.6±3.07%, 82±4.15%, respectively. Bulk density of uncoated and bio fertilizer coated seeds were 0.629±0.02 g/cc and 0.641± 0.03 g/cc, respectively. Geometric mean diameters of uncoated and coated seeds were 7.32±0.45 mm and 7.33±.45 mm, respectively. The hopper of seed drill was designed based up on the angle of repose of mild steel which influences on free flow of sesds. The angle of repose for mild steel surface was observed as 26.9±5.61 and 29.51±4.23 degree for uncoated and bio-fertilizer coated chickpea seeds, respectively.

Key words: Angle of repose, Bulk density, Geometric mean diameter, Sphericity, Static coefficient of friction.

1. Introduction

India is one of the major pulses growing country of the world, accounting roughly for one third of total world area under pulse cultivation and one fourth of total world production. Pulses occupy a key position in Indian diet and meet about 30 per cent of the daily protein requirement. Among the pulses; chickpea is a most important one (Jadeja *et al.*, 2019). Chickpea is an important winter season pulse crop in India grown as a dry pulse crop or as a green vegetable with the former use being most common. It ranks first in area cultivated in India, grown over an area of 8.11 million hectares with production of 5.9 million tones with average productivity of 727 kg/ha (Anonymous, 2016). India contributes 75% of the total world production of chickpea followed by Turkey and Pakistan. India grows chickpea on about 6.67 million ha area producing 5.3 million tonnes which represents 30% and 38% of the national pulse acreage and production, respectively. India is major producer of chickpea but productivity is very low as compared to other chickpea producing countries. India is also major importer of chickpea because of more consumption. So there is urgent need to increase the productivity of chickpea. Now a day's higher usage of chemical fertilizer leads to deterioration of soil health. The bio-fertilizers are soil friendly it will provide soil nutrient without deterioting the soil health. So, Mechanisation is needed for increasing the productivity of chickpea. Efficient seeding depends on accuracy, precision and uniformity of seed placement. Indian farms have been traditionally sown by using manual and bullock drawn seeder. The most popular traditional methods of sowing like broadcasting, line sowing behind the plough. Mechanization improves precision, effectiveness, timeliness of operation and it is economical as well. The physical proprieties of seeds are important factors which determine the design values of metering mechanism. Hence study was undertaken to determine the physical properties of chickpea seed. Laxmikath *et al*. (2020) conducted to investigate physical properties of chickpea seeds at different levels of moisture content 16.41-25.65% (d.b.). The average value of length, width and thickness varied from 8.27-9.39 mm, 6.16-7.02 mm and 5.59-6.62 mm, respectively. Geometric mean diameter and sphericity varied 6.57-7.58 mm and 79.55– 80.77 percent, respectively. Average value of bulk density and true density varied from 722.02 to 689.05 kg m^{-3} and 875.09 to 850.51 kg m^{-3} respectively. The angle of repose ranged between 22.34 to 25.52°. The roundness of chickpea ranged between 0.77 to 0.80, seed weight 230.81 to 248.11

respectively. Davies (2010) studied the engineering properties of three different varieties of melon seeds and four frictional surfaces were used, namely, glass, plywood, galvanized steel and concrete for determination of static friction and angle of repose and reported that the highest coefficient of friction was observed in concrete surface for all the three varieties of melon investigated. Karaj *et al.* (2010) determined the engineering properties of *Jatropha curcas* seeds. It was reported that coefficient of static friction of seeds was higher on rubber surface and lowest on stainless steel. The coefficient of static friction was observed higher on all surfaces for kernels than for seeds. It was found that angle of repose of kernels was higher than for seeds. Mollazade *et al.* (2009) determined the some of engineering properties of cumin seed. Three surfaces were used for determination of engineering properties *i.e.*, glass, galvanized iron sheet and plywood. It was reported that the static angle of repose (43-49 deg), dynamic angle of repose (47-56.6 deg) and coefficient of static friction on the three surfaces: glass (0.48-0.77), galvanized iron sheet (0.36-0.73), and plywood (0.57-0.69). Sinha *et al.* (2019) studied the physical and engineering properties of 20 chickpea seeds such as length, width, thickness, sphericity, aspect ratio, geometric mean diameter, thousand seed weight, bulk density and moisture content. The average length, width, thickness, sphericity, aspect ratio, geometric mean diameter, thousand seed weight, bulk density and angle of repose are 8.48 mm, 6.45 mm, 6.03 mm, 0.81, 75.54 %, 6.90 mm, 244.85 g, 709.55 kg/m³ and 19.81 % respectively. This study is useful for design of metering mechanism for chickpea seeds.

2. Materials and Methods

Physical and engineering properties were determined in the laboratory of Division of Agricultural Engineering, IARI New Delhi. The chickpea crop variety BG 1003 was selected for laboratory testing and field experiment. The relevant properties of chickpea seeds were measured for coated and uncoated seeds. Experiments are carried out at two levels namely uncoated seed (S_1) and bio-fertilizer coated seed (S_2). *Rhizobium* bio-fertilizer coating was done taking sugar solution as adhesive for bio-fertilizer. Size of seed in terms of length, breadth and thickness were measured using digital vernier calliper. Twenty seeds were randomly selected from bulk and subjected for size analysis with three replications.

The shape of the chickpea seed was reckoned as roundness and sphericity. The geometric mean diameter (Dg), arithmetic mean diameter (Da) mm, roundness % and sphericity of the seeds were computed by following equations (Laxmikath *et al*., 2020).

$$D_g = (abc)^{1/3}$$

$$D_a = \frac{(a+b+c)}{3}$$

$$\emptyset = \frac{(abc)^{1/3}}{a}$$

Where

a = Length, b = Breadth and c = Thickness

Dg = Geometric mean diameter,

Da = Arithmetic mean diameter and

Ø = Sphericity

An empty container (150mL) was weighed using a digital balance to the nearest 0.0001g. The container was filled with a sample and the material was slightly compacted to ensure absence of large void spaces. The container and the sample were then weighed. Ten replications were carried out (Laxmikath *et al*., 2020). The bulk density of sample was calculated from the following given equation.

$$\text{BD} = \frac{\text{M}}{\text{V}}$$

Where,

BD = Bulk density, g/cm^3

W = Weight of seed, g

V= Volume of cylinder, cm^3

The apparatus used for measuring dynamic angle of repose consisted of a funnel with an adjustable throat opening mounted on a stand. A circular plate, with two centring arms, was mounted in the funnel below the adjustable throat. The funnel was filled with seeds by keeping its adjustable throat closed. The throat was fully opened to allow free flow of seeds over and around the plate mounted beneath the funnel. At the end of process, a heap-cone of the seed was formed on the plate. From the heap cone, base diameter and height of cone were measured (Laxmikath *et al.*, 2020). The angle of repose was calculated with the following relationship:

$$\emptyset = \tan^{-1}\left(\frac{h}{r}\right)$$

Where,

Ø = Angle of repose, degrees

h = Height of cone, cm

r = Radius of heap, cm

The coefficient of static friction of two surfaces *i.e.*, aluminum and mild steel were measured for the seed by using inclined plane method. The material was kept on a horizontally placed surface and the slope was increased gradually. The angle (α) at impending slide was recorded. The coefficient of static friction was expressed by tanα. The procedure was repeated 20 times and the mean value was calculated. The experiment was conducted for all the levels of test variables as shown in Table 1.

Table 1: Seed properties and levels of test variables

Sl. No.	Properties	Test variables	Levels of test variables
1	Size	Chickpea seeds	S_1 –Uncoated seed
2	Shape		S_2-Bio-fertilizer coated seed
3	Bulk density and True densit		
4	Angle of repose		
5	Coefficient of static friction	*Two surfaces	*Aluminum and mild steel

3. Results and discussion

The effect of *Rhizobium* coating on physical and engineering properties of chickpea seed was studied and results are presented in below.

3.1 Physical properties

Table 2: Physical and engineering properties of chickpea seeds

Parameters	**Level of test variables**	
	Uncoated	**Coated**
Length (mm)	9.017 ± 0.62	9.065 ± 0.44
Breadth (mm)	7.059±0.69	7.144±0.90
Thickness (mm)	6.57±0.54	6.9±0.22
GMD (mm)	7.324±.45	7.32±0.45
Sphericity (%)	81.6±3.07	82±4.15
Roundness (%)	87.23 ±2.13	87.36±2.72
Bulk density (g/cm^3)	0.629±0.02	0.641±0.03
Seed weight (1000)	236.5±2.32	237.25±3.22
Angle of repose	26.9±5.61	22.75±4.9
Coefficient of friction	0.603±0.12	0.576±4.9

3.2 Size of the seed

The size of the seed specified the spatial dimensions are given in Table 3. The mean length, breadth and thickness of uncoated and bio-fertilizer coated chickpea seeds was observed 9.01±0.62 mm, 7.059±0.69 mm, 6.57±0.54 mm and 9.06±0.44 mm, 7.144±0.90 mm, 6.9±0.22 mm, respectively. Both mean length and breadth thickness of coated seeds is slightly higher as compared to uncoated chickpea seed. However, the differences between coated and uncoated were found non-significant. These values are agreement with Tavakoli *et al.* (2009).

3.3 Shape of the seed

The shape of the seed, in terms of roundness and sphericity are presented in Table 2. The sphericity and roundness of the chickpea seed at different levels were found in the range of 82-84 % and 85-87 %, respectively. The roundness and sphericity of uncoated and bio-fertilizers coated chickpea seeds found to be 87.23 ±2.13 %, 87.36±2.72 % and 81.6±3.07 %, 82±4.15 %, respectively. There is no significant difference was observed in sphericity and roundness for two levels of chickpea seeds but the variations were marginal. These values are agreement with Salah Ghamari *et al.* (2014).

3.4 Bulk density and True density of seed

The average bulk density of the seeds for uncoated and bio-fertilizer coated chickpea seeds was observed as 0.629 g/cm^3 and 0.641 g/cm^3, respectively. The average bulk density of seeds for uncoated and bio-fertilizer coated chickpea as shown in Table 2. The average bulk density of bio fertilizer coated seeds was higher as compared to uncoated seeds. However, it was found statistically non significant. These values are agreed with Laxmikath *et al*. (2020).

3.5 Thousand seed weight

The mean value of the thousand seed weight of uncoated and bio-fertilizer coated chickpeas seeds as shown in Table 5. The mean value of the thousand seed weight of uncoated and bio-fertilizer coated chickpeas seeds were found to be 236.65 g and 237.25 g, respectively. The thousand seed weight of bio-fertiliser was slightly higher than uncoated chickpea seeds. The differences were subtle as statistically non significant. These values are agreed with Sinha *et al.* (2019).

3.6 Angle of repose and coefficient of static friction

The angle of repose and coefficient of static friction for uncoated and bio fertilizer coated chickpea seeds as shown in Table 4 and 5. The angle of repose for uncoated seed was significant difference with coated seed. The mean value of angle of repose for uncoated and bio fertilizer coated seeds found to be 29.6 and 26.9, respectively. The highest value of angle of repose was observed as 29.6 for uncoated with the mild steel surface. For the aluminium surface, mean values of coefficient of static friction for uncoated and bio-fertilizer coated seeds was observed as 0.60 and 0.392, respectively. The highest value for coefficient of static friction was recorded for mild steel surface for uncoated seed. However, significant difference was observed in angle of repose between uncoated and coated seed. It might be due to change in surface texture of coated seed. Hence, the angle of repose has to be considered for proper designing the hopper to free flow of seed. It imparts that it is necessary to modify hopper of exiting machine for coated seed handling. The mean weight of bio fertilizer coated chickpea seeds slightly increased as compared with uncoated seeds. The highest value of angle of repose was observed as 34 for uncoated seed for mild steel. Therefore, considering the ease and economy of fabrication, the mild steel surface was selected for the experiment.

The statistical analysis was conducted with T-test method in different levels of parameters were used for the experiment as shown in Table 6. The parameters are length, breadth, thickness, geometric mean diameter, 1000 seed weight and sphericity was found to be non significant at 5 per cent level of significance and the angle of repose was found to be significant at 5 per cent level of significance.

Table 3. Size of chickpea seed at level of coated

Seeds	**Uncoated**	**Bio-fertilizer coated**
Length (mm)		
Range	8.55-9.75	8.47-9.53
Mean	9.017	9.065
C.V (%)	5.34	3.96
Breadth		
Range	6.36-7.83	6.58-7.89
Mean	7.059	9.065
C.V (%)	7.06	3.96
Thickness		
Range	5.36-7.17	6.58-7.89
Mean	6.57	7.144
C.V (%)	10.20	5.48

Table 4. Engineering properties of chickpea seed

Seeds	Uncoated		Bio fertilizer coated	
Angle of repose	MS	Al	MS	Al
Range	23-34	22-29	23-34	22-28
Mean	29.6	24.4	26.9	24.38
C.V (%)	14.17	10.53	14.17	9.48
Bulk density (g/cc)				
Range	0.595-0.655		0.622-0.678	
Mean	0.629		0.641	
C.V (%)	2.87		2.57	

Note: C.V Coefficient of variation (%)

Table 5. Angle of static friction and 1000 seed weight of uncoated and coated seed.

Seeds	Uncoated		Bio fertilizer coated seed	
1000 seed weight(g)				
Range	234.5-239		231-240.52	
Mean	236.65		237.254	
C.V (%)	0.697		1.17	
Angle of static friction	MS	Al	MS	Al
Range	0.344-0.754	0.424-0.674	0.364-0.687	0.249-0.547
Mean	0.603	0.509	0.576	0.392
C.V (%)	19.98	16.21	17.53	27.42

Table 6. ANOVA table for Independent samples test for chickpea seed dimensions

Seed Dimensions	Comparison between treatments	T-Test for Equality of Means			
		t-value	DF	Sig	Std. Error Difference
				(2-trailed)	

length	T_1-T_2	-.253	18	0.803	0.19004
Breadth	T_1-T_2	-.424	18	0.677	0.20055
Thickness	T_1-T_2	-1.570	18	0.134	0.21973
Geometric mean diameter	T_1-T_2	0.000	18	1.000	0.14916
Angle of Repose	T_1-T_2	2.073	18	0.047	2.00146
1000 seed weight	T_1-T_2	-.590	18	0.563	1.02421
Sphericity	T_1-T_2	-.841	18	0.412	1.21936

Note: T_1= Uncoated chickpea seed.

T_2= bio-fertilizer coated chickpea seed.

Conclusion

The study well evaluated the effect of rhizobium coating on physical and engineering properties of chickpea seed. The physical proprieties of seeds are important factors which determine the design values of metering mechanism. Chickpea productivity must be increased through mechanisation. The accuracy, precision, and uniformity of seed placement are critical for efficient seeding. This study is useful for design of metering mechanism for chickpea seeds.

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