The Pharma Innovation Journal 2022; SP-11(10): 1331-1333

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(10): 1331-1333

www.thepharmajournal.com
Received: 02-07-2022
Accepted: 07-08-2022

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Physical and mechanical properties of cotton seeds

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Abstract
Some physical properties of cotton seeds (*Gossypium hirsutum* L) were determined at the moisture content of 7.8 per cent (w.b.). The size, sphericity, surface area, geometric mean diameter, test weight of grains, true density, bulk density and porosity were mm, 0.6216, 131.154 mm^2 , 6.46 mm, 112.216 g, 1.1561 g/ml , 0.6477 g/ml , and 36.106 %, respectively. The mechanical properties of the cottonseeds viz., angle of repose, coefficient of static friction using different surfaces were also determined and the values were 45.33º, 1.104 (mild steel), 1.2912 (play wood), 1.038 (glass) and 1.11 (Perspex), 1.018 (Asbestos), respectively. The terminal velocity of the grains was 10.84 m/s.

Keywords: Cotton seeds, physical properties, moisture content, static friction, terminal velocity

1. Introduction
Cotton is one of the most important commercial and fiber crops of India. It plays a key role in the agricultural and industrial economy. Cotton provides the basic raw material like a cotton fibre and it is supply to the cotton textile industry. In India cotton provide great opportunity to the direct livelihood 6 million farmers. About 40-50 million people are involved in cotton trade and its processing. Cotton is grown in an area of 105 lakh ha having a production and productivity of 351 lakh bales and 568 kg/ha respectively, widely grown in Maharashtra, Telangana and Gujarat states. India is the largest producer of Cotton accounting for ¼th of the global cotton production.
The cost of the cotton seed is very high and require to be planted single seed per hill precisely otherwise seed wastage will increase the cost of planting, resulting in huge loss to the farmer. The commonly available planters are not precise and 2 or 3 seeds per hill planted and available some precision seed drill are very high cost and not affordable to small and marginal farmers, hence this research project is aimed by develop a microcontroller based precision cotton planter with affordable cost which can place the seed accurately.
The main purposed of sowing is to place the seed at a certain spacing and depth in the seed bed. Precision seeders place seeds at the required spacing and provide a better growing area per seed. A seeder should place a seed in an environment in which the seed will reliably germinate and emerge. To maximize the potential yield of cotton, precision seeding of crop is paramount importance to achieve reduced seed rate, good crop geometry, and poor seed placement and sound crop stand. The manual application of seed, without suitable machines, fails to achieve the goals of proper seeding and increased cost of cultivation. Design of a precision planter needs optimization of Electronic and mechanical planter, Seed rate, Spacing, Seed placement index, Comparison different design parameters including crop, soil and machine. (P. rajah)
In order to design and develop a microcontroller based precision cotton planter, cotton seed physical and mechanical properties is necessary, those are linear dimensions, sphericity , thousand seed mass $m_{1000,}$ projected area $A_{p,}$ bulck density , true density, volume, porosity P_{f} , terminal velocity $V_{t,,}$ static friction of coefficient against different surfaces of materials and shelling resistance R_s

2. Material and Methods
The raw material i.e. Bt cotton variety was procured from fertilizer shop, Guntur. Andhra Pradesh. The seeds were cleaned manually to separate the any damaged seeds in that package, before conducting the experiments.

The initial moisture content of grains was determined as per the method suggested by AOAC, 2000 [8]. The moisture content of sample was determined by hot air oven method. The samples were placed in a hot air oven maintained at 105 °C for 3 hours. After taking out from the oven, the samples were cooled in desiccator and weighed. The average moisture content of the samples on wet basis was calculated using the following equation:

$$\text{Moisture content on wet basis (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where,
W1 = Weight of sample before drying, g
W2 = Weight of sample after drying, g
The size (length, width and thickness) of randomly selected 50 grains was measured using a digital vernier calipers having the least count of 0.01 mm.
The sphericity (Φ) of Finger millet grains was calculated by using the following equation (Mohasenin, 1986) [C].

$$\phi = \frac{(LwT)^{\frac{1}{3}}}{L} \ldots 3.1$$

Where,
L = Length of the seeds
W = Width of the seeds
T = Thickness of seeds

The Geometrical mean diameter of cotton seeds was calculated by measuring their linear dimensions of randomly selected grains, using digital Vernier calipers with a least count 0.01 mm.

The GMD was calculated by using the following formula (Mohasenin, 1986) [9].

$$Dg = (L \times W \times T)^{1/3} \ldots 3.2$$

The surface area of cotton seed was calculated using the following formula (Mohasenin, 1986) [9].

$$\text{Surfacearea, } S = \pi D_g^2 \ldots 3.3$$

Where,
Dg is the geometrical mean diameter.
For determination of test weight of seeds, thousand cotton seeds, unbroken and sound seeds, from three randomly drawn samples were hand counted and weighed using a digital balance (HTR-220E, Essae-TeraokaPvt. Ltd., Bangalore), of accuracy 0.0001 g and their average weights were recorded. The mean values were reported.
The bulk density (BD) was determined by using measuring cylinder of volume 1000 ml. The cotton seeds were filled into the measuring cylinder and the top of the cylinder was levelled off. The grains were then weighed using a digital electronic balance. The bulk density of cotton seeds was calculated using the following formula:

$$\text{Bulk density } \left(\frac{g}{mL}\right) = \frac{\text{Weight of grains,g}}{\text{Volume of grains including void space ,mL}} \ldots. 3.4$$

The apparatus used for measuring true density of grains consisted of 250 ml jar and digital weighing balance. 100 ml of toluene was taken in to the measuring cylinder and a known weight of seeds sample was poured into the measuring cylinder. The displacement of the toluene level was recorded as the true volume of the grains without void space. The true density was measured using the following formula (Mohasenin, 1986) [9].

$$\text{True density} = \frac{\text{Weight of seeds,g}}{\text{Volume of seeds without void space ,ml}} \ldots..3.5$$

Porosity of grains was calculated by using the following formula

$$\text{Porosity}(\%) = \left(1 - \frac{\text{Bulk Density}}{\text{True Density}}\right) \times 100 \ldots 3.6$$

Angle of repose is important in designing a metering mechanism of plater. When a granular material is allowed to flow freely from a point into a pile, the angle which the side of the pile makes with horizontal plane is called angle of repose. (IS: 6663-1972) It is influenced by size, shape, moisture content and orientation of the particles. Angle of repose of grains was calculated using an apparatus consists of a circular platform immersed in a box filled grains. The equipment is supported by three legs and is surrounded by a metal funnel leading to a discharge hole. The seeds are allowed to escape from the box.

The angle of repose,ϕ, is calculated by using the following formula

$$\phi = \tan^{-1}\left(\frac{2H}{D}\right) \ldots.3.7$$

Where,
Φ= Angle of repose, degrees
H= Height of the cotton seeds pile formed, mm
D= Diameter of the circular disc, mm

Coefficient of static friction on three different surfaces, namely mild steel, play wood, Perspex, glass and asbestos was measured by the inclined plane method. Grains were kept on an adjustable tilting plate and the slope was increased gradually. The angle at which the material just started to move downward was recorded (α). Coefficient of static friction was calculated from the following relationship.

$$\mu = \tan \alpha \ldots\ldots 3.8$$

Where,
μ = Coefficient of static friction
α = Angle of tilt, degrees

The wind tunnel consists of a 0.25 hp centrifugal blower, plenum chamber, vertical Perspex tube, air flow control ring and inlet pipe. The vertical Perspex tube of 923 mm length of 40 mm internal diameter was fixed at the top of the plenum chamber with the help of three screws and a height of 500 mm was marked on the tube. At the top of the vertical tube, the opening was closed with Perspex sheet and covered with air control ring which was graduated around its periphery. The ring opening was closed upto 23 mm with Perspex sheet. By operating the ring, the air flow rate in the tube was controlled. The air velocity is measured using a digital anemometer at top end of a Perspex tube.

Results and Discussion

The length and width of 10 cotton seeds were measured. Sphericity, geometrical mean diameter and surface area were calculated and presented in Table 1. It was observed that the mean±standard deviation values for length, width, thickness, GMD, sphericity and surface area of cotton seeds were found to be 9.917±0.6751 mm, 4.801±0.3139 mm, 4.659±0.1454 mm, 6.46±0.2913, 0.6216±0.048298 and 131.1536±11.56058 mm^2 , respectively. The shape of cotton seed was spheroid with a sphericity of 0.6216.

Thousand cottonseeds were counted and weighed for determination of test weight of sample. The experiment was repeated five times and the mean±standard deviation value was calculated and the results are presented in Table1. The mean±standard deviation value of test weight of cotton seeds was observed as 112.216±0.779378 g.

The bulk density and true density of cotton seeds were determined five times and the porosity values are calculated using eq. 3.4. and 3.5. The results are presented in Table1. The mean±standard deviation values of bulk density, true density and porosity were found to be 0.64768±0.009148 g/ml, 1.1561±0.044 g/ml and 36.106±1.314265% respectively.

Table 1: Physical and mechanical properties of cotton seeds

Physical properties	Units	No. of observations	Mean	Std. dev
Length	mm	20	9.917	0.6751
Width	mm	20	4.081	0.3139
Thickness	mm	20	4.659	0.1454
Moisture content	%	10	7.8	0.0894
Sphericity	%	20	0.622	0.0482
Surface area	mm^2	20	131.15	11.561
GMD	mm	10	6.46	0.2913
True density	g/ml	10	1.1561	0.044
Bulk density	g/ml	10	0.6477	0.0091
Porosity	%	10		1.3143
Test weight of grains	g	10	112.22	0.7793
Porosity	%	10	36.106	1.3143
Terminal velocity	m/s	10	10.84	0.9685
Angle of repose	deg	10	45.33	0.9431

The angle of repose of cotton seeds was determined five times and the results are presented in Table1. The mean±standard deviation value of angle of repose of cotton seed was found to be 45.33±0.9431˚.

The moisture content of cotton seeds was determined five times and moisture content is observed as 7.8±0.894427% (wb).

The coefficient of static friction of cotton seeds on mild steel, perspex surfaces, play wood, and glass were measured ten times and the values are presented in Table 1. It was observed that the coefficient of static friction obtained for mild steel and lowest for glass material. The coefficient of static friction was in the order of Play wood > Perspex sheet> Mild steel > Glass > Asbestos. It was observed that the mean and standard deviation values of coefficient of static friction are found to be 1.292±0.086429, 1.114±0.130499, 1.104±0.067676, 1.038±0.07328 and 1.018±0.040866 for play wood, Perspex material, Mild steel, Glass and Asbestos materials respectively.

Terminal velocity of cotton seeds was determined five times and it was observed as average value is 10.84 m/s.

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