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# Study on some engineering properties of cotton seeds in relation to the development of a tractor operated seed dibbler

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**Abstract**
Planting is a critical field operation that has direct impact on the germination rate and subsequent yield of field crops. Cotton, being a major cash crop needs to be planted precisely as the cost of seeds is quite high. The machineries available for planting of cotton pose many problems besides being expensive. Hence, a tractor operated seed dibbler was developed for dibbling of cotton. Engineering properties of cotton are important consideration in developing any planting operation. Engineering properties help in designing various machine and operational parameters like type of seed metering mechanism, seed hopper capacity, angle of seed metering plate, speed of operation *etc*. ACH5 variety of cotton was selected in the present study and various engineering properties *viz*., size, sphericity, moisture content, bulk density, thousand seed weight, angle of repose and coefficient of friction were determined. The results of the study revealed that size, sphericity and moisture content of the cotton seeds were 5.53 mm, 0.66 and 7.53 % (d.b), respectively. Bulk density of cotton seeds was measured to be 575.05 kg $m^{-3}$. Thousand seed weight, angle of repose and coefficient of friction of cotton seeds were determined as 77 g, 31.96 degree and 0.535, respectively. Functional components of the seed dibbler were designed on the basis of values of engineering properties obtained in the study.

**Keywords:** Engineering properties, cotton, tractor operated seed dibbler

## Introduction
India is an agriculture dependent country. The main stay of national economy is agricultural land. It accounts for livelihood of about 65 per cent of country's population. In order to sustain and feed the projected population of 140 crores by the year 2025, the productivity has to be increased by almost 100 % from the current level by practicing intensive agriculture (Pandey, 2009) [6]. In present scenario, leveraging the available natural resources and technological advances in the field of agriculture is the only way to make viable progress. Sustainable improvement in the livelihoods of poor farmers in developing countries like India depends largely on the adoption of improved and mechanized farming systems.

Mechanization in India is in ameliorating stage with some operations completely mechanized and some need to be mechanized. Non-availability of manpower during peak crop seasons is a major problem. Agricultural mechanization is one such concept which encompasses the technical improvements in all the field operations for varied cropping practices and provides feasible solution in attaining not only the self sufficiency but also in enhancing the productive utilization of natural resources. Mechanization level of sowing and planting operation for various major crops ranges between 20 and 60 % (Mehta *et al*., 2019) [3].

Planting is one of the cardinal crop management practices. The important variables influencing plant establishment are seed characteristics, external physical, chemical and biotic environment and crop management. Mechanical dibbling technique is gaining importance under precision planting aspect as it possesses advantages over manual dibbling such as reduced labour, higher accuracy in depth of planting, precise seed spacing, compact design and easy to handle. Dibble planting or dibbling involves making holes or opening up soil and placing the seeds in the hole. Opening the hole and placing in the hole can be two separate operations or can be carried out simultaneously as per the functional requirement. Seed dibbler is a type of precision planting equipment which is used for planting of row crops without much disturbance of soil by forming the holes and placing the seeds precisely in the formed holes. Seed dibblers are classified based on the shape of hole making component as spade type, bucket type and punch type.

Cotton (*Gossypium hirsutum*) is the most important fibre crop in India. It contributes dominantly for the industrial and economical development of the country.

According to ICAR-Central Institute of Cotton Research, Nagpur, during 2017-18, the total area under cotton in India was 12.44 mha and total production was 370 lakh bales with a productivity of 505.46 kg ha$^{-1}$ (Anon., 2020) [1]. Among states, Maharashtra contributes major share in area under cotton and production followed by Gujarat and Telangana. Karnataka state has an area of 0.546 mha under cotton cultivation with production and productivity being 18 lakh bales and 560.44 kg ha$^{-1}$, respectively.

Knowledge of engineering properties of seeds is of paramount importance to develop efficient and economical planting machinery. Delivery of seeds through any planting machinery is influenced by size, shape, sphericity, density and angle of repose of seeds. The impact of seeds on the internal components of the planter is dependent on the coefficient of friction of seeds on the fabricated surface material (Jayan and Kumar, 2004) [2]. Engineering properties also play vital role in designing various aspects of seed metering mechanism such as cells size, inclination angle of seed plate and material of seed plate so that maximum seed singulation is achieved. Hence, considering the above facts and figures, a study was conducted to determine various engineering properties of cotton seeds in the process of development of a seed dibbler.

Ozarslan (2002) [5] evaluated some physical properties of delinted and bare cotton seed. They reported that average length, width and thickness of cotton seeds ranged from 9.02 to 9.19, 4.70 to 4.86 and 4.25 to 4.45 mm as the moisture content increased from 8.33 to 13.78 % (d.b.), respectively.

Jayan and Kumar (2004) [2] investigated physical properties of maize, red gram and cotton seeds as design parameters for a planter. The results revealed that the roundness of maize, red gram, and cotton were 1.14 ± 0.14, 1.15 ± 0.10, and 1.26 ± 0.10 respectively, while sphericity of these seeds in the natural rest position were 0.621 ± 0.065, 0.750 ± 0.016, 0.550 ± 0.016 respectively. The mean angle of repose of maize, redgram, and cotton were 22.1 deg, 28.48 deg, and 21.48 deg respectively. To ensure free flow of seeds, the slope of the seed hopper was fixed at 30 degree.

Ramesh *et al.* (2015) [7] studied the physical and mechanical properties of cotton seeds through image analysis technique. They reported that mean length, width and thickness of the selected varieties of cotton seeds were 8.84, 5.00 and 4.50 mm respectively. The projected area and sphericity of seeds of three varieties were 36.17, 39.86 and 29.73 mm$^2$ and 0.61, 0.64 and 0.67 respectively. The average unit mass, 1000 seed mass, volume, true density, bulk density and porosity varied between 0.079 to 0.098 g, 83.86 to 94.68 g, 89.63 to 99.47 mm$^3$, 1107.68 to 1285.43 kg m$^{-3}$, 480.56 to 589.14 kg m$^{-3}$, 46.76 to 53.96 per cent for all the selected varieties.

Vasuki and Tajuddin (2015) [9] investigated the engineering properties of cotton seeds *viz.*, size, sphericity, thousand seed mass, bulk density, angle of repose, coefficient of friction and true density. They reported that sphericity ranged from 0.636 ± 0.016 to 0.687 ± 0.02 mm and thousand seed mass from 61.60 ± 0.089 to 93.6 ± 0.120 g. The bulk density varied from 613 to 648 kg m$^{-3}$. The angle of repose varied from 19.2 to 26.3 degrees. The static co-efficient of friction of cotton seed was determined on four materials namely, stainless steel (0.28 to 0.35), mild steel (0.38 to 0.43), ply wood (0.40 to 0.45) and rubber (0.43 to 0.46).

## Material and Methods

Engineering properties of cotton seeds namely, seed size, sphericity, moisture content, bulk density, thousand seeds weight, angle of repose and coefficient of friction were determined by following standard procedures and using suitable equipment (Fig.1). The procedures used in the determination of various engineering properties are discussed below.

### Seed size

Size is defined as the equivalent diameter of a seed. The size of seeds was determined in terms of length (l), width (b) and thickness (t). 50 samples of each selected type of seeds was taken and the dimensions l, b and t were measured at three major axes with the help digital screw gauge having least count of 0.01 mm. Size of each seed in terms of equivalent diameter ($D_e$) was also determined by using following formula (Mohsenin, 1970) [4].

$$D_e = (l \times b \times t)^{\frac{1}{3}}$$

### Sphericity

Sphericity is defined as the ratio of the surface area of a sphere with the same volume as the seed to the surface area of the seed. The sphericity of the seed was determined using the following equation (Mohsenin, 1970) [4].

$$\varphi = \frac{(l \times b \times t)^{\frac{1}{3}}}{l}$$

### Moisture content of seeds

Moisture content of seeds of cotton seeds at the time of sowing was determined by oven dry method. In this method, seed samples were weighed and oven dried at 105ºC for 24 h. The samples were taken out after 24 h and cooled in desiccator. The dried weight of seeds was taken on the weighing balance. The moisture content of seeds on dry basis was calculated using the ensuing relationship (Sahay and Singh, 1994) [8].

$$MC = \frac{W_i - W_d}{W_i} \times 100$$

where,
MC = moisture content, %
$W_i$ = initial weight of sample, g
$W_d$ = dried weight of sample, g

**Fig 1:** Determination of moisture content and seed size of cotton

### Bulk density

Bulk density of seeds is weight of seeds per unit volume. It was measured by filling a trapezoidal shaped container of volume 225000 mm$^3$ with cotton seeds from a height of 150 mm at constant rate without compacting the seed mass. Bulk

density was calculated as the ratio of weight of seeds in the container to the volume of container expressed as kg $m^{-3}$.

**Thousand seed weight**
Thousand seed weight was determined for ten random samples of 1000 seeds each on an electronic balance having sensitivity of 0.001 g.

**Angle of repose**
The angle of repose depicts the ease with which the seeds flow. Angle of repose was determined on an apparatus which had a conical container with discharge opening at the bottom and a circular plate placed under it for dropping of seeds. The conical container was filled with seeds by covering its discharge opening. Then the opening was slowly released to facilitate formation of heap on the circular plate. Then the angle of repose was calculated using the following relationship (Mohsenin, 1970) [4].

$$\theta = \tan^{-1}\left(\frac{h_0}{r}\right)$$

where,
$\theta$ = Angle of repose, deg
$h_0$ = Height of heap, m
r = Radius of heap, m

**Coefficient of friction**
Coefficient of friction of seeds on MS sheet was measured using the standard apparatus. The seeds of known weight were filled in a wooden container attached with a string having loading plate at its one end and placed on an MS sheet. The weights were added to the extension of seed container until it moved slightly from its place. The procedure was repeated for five different samples. The coefficient of friction of seeds was calculated by using following relationship (Mohsenin, 1970) [4].

$$\mu = \frac{F}{N} \quad \ldots. (3.5)$$

where,
$\mu$= Coefficient of friction
F = Frictional force (force applied)
N = Normal force (weight of the grain)

**Results and Discussion**
Various engineering properties of selected seeds *viz*., size, sphericity, moisture content, bulk density, thousand seed weight, angle of repose and coefficient of friction were determined by standard procedure as explained above. The results of various engineering properties of cotton are presented in Table 1.

**Seed size**
Size of seeds is expressed as the cube root of its linear dimensions namely, length, breadth and thickness. The minimum and maximum sizes of the cotton seeds recorded were 5.18 and 5.83 mm with average size of 5.53 mm.

**Sphericity**
It is the ratio of size of seed to its maximum linear dimension. The minimum sphericity of cotton seeds was obtained as 0.60 and maximum value was 0.70 with an average of 0.66.

**Moisture content of seeds**
Optimum moisture content of seeds is essential in achieving better planting performance and favorable germination characteristics. Moisture content of selected seeds was determined before the planting operation using hot air oven method. Moisture content of cotton seeds varied from 7.48 to 7.66 % (d.b) with average value of 7.53 % (d.b).

**Bulk density**
Bulk density of seeds is expressed as the weight of uncompacted seed mass per unit volume. Average bulk density of cotton seeds was determined as 575.05 kg $m^{-3}$ and it varied between 545.60 and 613.16 $kgm^{-3}$.

**Thousand seed weight**
Thousand seed weight of cotton seeds was measured using an electronic weighing balance having sensitivity of 0.001 g. Thousand seed weight of cotton seeds varied from 72 to 81 g with an average value of 77 g.

**Angle of repose**
Angle of repose influences the flow characteristics of seeds through seed hopper and seed tube. The average angle of repose of cotton was determined as 31.96 deg with minimum and maximum values of 30.96 and 32.62 deg.

**Coefficient of friction**
The coefficient of friction between the selected seeds and the MS sheet material was determined. Coefficient of friction of cotton seeds varied from 0.40 to 0.67 with an average value of 0.535.

**Table 1:** Engineering properties of cotton and maize

| S. No. | Properties | Values |
|---|---|---|
| 1 | Variety | ACH5 |
| 2 | Size, mm | 5.53 |
| 3 | Sphericity | 0.66 |
| 4 | Moisture content, % (d.b) | 7.53 |
| 5 | Bulk density, kg $m^{-3}$ | 575.05 |
| 6 | Thousand seed weight, g | 77.00 |
| 7 | Angle of repose, deg | 31.96 |
| 8 | Coefficient of friction | 0.535 |

**Conclusions**
Seed characteristics are important in designing various working components of the planting equipment. In present study, a seed dibbler was developed for mechanical dibbling of cotton. Different engineering properties of cotton were determined as inputs in the seed dibbler design process. Average size and sphericity of cotton seeds were determined as 5.53 mm and 0.66 respectively. Average moisture content, bulk density and thousand seed weight of cotton were 7.53 % (d.b), 575.05 kg m-3 and 77 g, respectively. Angle of repose and coefficient of friction were found to be 31.96 deg and 0.535.

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