Biological Forum – An International Journal **15(4): 56-63(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Determination of Engineering properties of Cotton Seeds for the Development of Microcontroller based Precision Planter

Lalit Manohar Yadav[1]*, Sushilendra[2], Sunil Shirwal[3], Vijayakumar Palled[4], Ananda N.[5], Mareappa Hirekurubaru[3] and Murali M.[3]

[1]Reseach Scholar, Department of Farm Machinery and Power Engineering,
College of Agricultural Engineering, University of Agricultural Sciences, Raichur (Karnataka), India.
[2]Associate Professor and Head, Department of Farm Machinery and Power Engineering,
College of Agricultural Engineering, University of Agricultural Sciences, Raichur (Karnataka), India.
[3]Assistant Professor, Department of Farm Machinery and Power Engineering,
College of Agricultural Engineering, University of Agricultural Sciences, Raichur (Karnataka), India.
[4]Professor and Head, Department of Renewable Energy Engineering,
College of Agricultural Engineering, University of Agricultural Sciences, Raichur (Karnataka), India.
[5]Assistant Professor, Department of Agronomy,
College of Agriculture, University of Agricultural Sciences, Raichur (Karnataka), India.

(Corresponding author: Lalit Manohar Yadav)*
(Received: 11 February 2023; Revised: 26 February 2023; Accepted: 08 March 2023; Published: 20 April 2023)
(Published by Research Trend)

ABSTRACT: Engineering properties are important in design and development of seed metering mechanism of planter which is responsible for uniform seed distribution so in this study engineering properties of the hybrid cotton seeds were determined. The conventional method to determine physical size seeds are time consuming and laborious process, whereas size determination using digital image analysis is a fast and time saving method, so in this study two methods were used to determine the physical size of hybrid cotton seeds (conventional and digital image analysis) and the outcomes of both methods were statistically analyzed. In the digital image analysis method, images of seeds were captured at 1258×1280 resolution and processed in Image J software for software estimation. The mean length, width, and thickness of cotton seeds measured with a vernier calliper were 8.55, 5.33, and 4.80 mm, respectively, and the mean length and width measured with digital image analysis were 8.76 and 5.63 mm. The spehericity of the seeds was the same for both methods, i.e., 0.70. In terms of length and width, there was a strong correlation between conventional method and digital image analysis method. The average values of moisture content, bulk density, true density, hundred seed weight, angle of repose of cotton seeds, and mild steel coefficient of friction ranged from 7.97 to 8.35 percent (w.b.), 586 to 591 kgm^{-3}, 1000 to 1008 kgm^{-3}, 10.43 to 10.9 g, 35.26° to 37.95°, and 0.46 to 0.65.

Keywords: Vernier calliper, digital image analysis, angle of repose and coefficient of friction.

INTRODUCTION

Cotton is one of the most important commercial crop in India and also known as the king of fibre crops (Soni and Rajput 2018). India is among the largest producer of the cotton in world and has share of 22 per cent in world cotton share (Aydogdu *et al.,* 2021). Being a very important commercial crop it is very important to safe handle the crop seeds and need to determine the engineering properties of cotton seeds which are very important in designing equipment or machine for aeration, seed handling, sowing operation, storing and processing (Ozarslan, 2002). In the development of microcontroller based precision planter for cotton, the engineering properties of seeds play a major role. Engineering properties of seeds namely, seed size, spehericity, moisture content, true density, bulk density, hundred seeds weight, angle of repose and coefficient of friction are important parameter that are useful in design of seed metering mechanism and also affect performance of seed metering device of planter or seed drill. In addition to this some of these physical properties will also influence in development of various other cotton processing machines like seed cleaner, grader, sorting machine, oil expelling machinery and transportation components in the processing plant.

Surface area and volume of seeds is an important physical characteristic in processes such as harvesting, cleaning, separation, handling, aeration, drying, storing, milling, cooking and germination (Igathinathane and Chattopadhyay 1998; Hsieh *et al.,* 1998). In order to design sizing and grading equipment as well as electrostatic separation from undesired materials, shape and size are crucial (Mohsenin, 1970). Owing to the irregularities and variation in shapes, surface profiles, and dimensions of specific food materials, it is very difficult to evaluate the actual surface areas of seeds or any other food grains. (Fıratlıgil-Durmuş *et al.,* 2010). Convnetionally length, thickness and width of seeds are generally measured using a vernier caliper which is very arduous and time-consuming procedure. The conventional experimental method needs to be upgraded with an advanced computing system in order to significantly reduce human error and save the time.

Digital image analysis is a new technique that allows for faster and more accurate size measurements without causing seed damage. Digital image analysis is the procedure in which digital image (camera captured) is transformed into digital values (Williams *et al.*, 2013). Maheshwari (2013) used image analysis to assess the quality of rice seeds and count the quantity of seeds. Nurcahyani and Saptono (2015) used a smartphone to detect the quality of husked rice with 96.67% accuracy. Lurstwut and Pornpanomchai (2017) evaluated seed germination using a mobile phone image of a rice seed. Ramesh *et al*. (2015) studied the properties of cotton seed about designing a pneumatic seed metering device. They measured linear dimensions of seed by image analysis technique. Tanska *et al.* (2005) employed an image processing technique to identify contaminants that are challenging to remove during the cleaning process as well as the geometrical characteristics of rapeseed. Kadlec *et al*. (2006) investigated the shape characterization of pea seeds in micro-wave drying using image analysis to determine the specific surface area. Ercisli *et al*. (2012) used an image processing system to determine the geometric mean diameter, spehericity, surface area, volume, shape factor, compactness, elongation, and shape index of ten walnut cultivars. Widiastuti *et al.* (2018) studied the image using a standard flatbed scanner to identify rice seed purity based on shape, texture and color, and to confirm the results using the grow out test (GOT) in the field.

The objective of this study to investigate engineering properties of the cotton seeds which are useful in the design and development of planter and also to determine the size of cotton seed by using two methods (conventional method and digital image analysis method).

MATERIAL AND METHOD

The SRCH-BG II variety of hybrid *Bt*-cotton seeds was taken from local market of Raichur district for the determination of engineering property. Engineering properties of cotton seeds namely seed size, spehericity, hundred seeds weights, true density, bulk density, moisture content, angle of repose and coefficient of friction were analyzed in the Engineering properties lab of the Food Processing department of College of Agricultural Engineering, University of Agricultural Sciences, Raichur. The following procedures for determining engineering properties of hybrid cotton seeds are discussed below.

Seed Size. The term "seed size" refers to the equivalent diameter of the seed. The physical size of seeds helped in designing cell size length, depth of seed plate and number of seeds to be required over cell surface of seed plate. The dimensions of the cotton seed were analyzed using two technique methods *viz.,* conventional method using vernier calipers and digital image analysis technique using ImageJ software. The following techniques were used for dimensions measurement.

Vernier Caliper. The seed size was measured in length (l), width (w), and thickness (t). The dimensions of cotton hybrid seed were measured by using digital Vernier Caliper (least count of 0.1mm) as shown in Fig. 1. Fifty samples of cotton hybrid seed with four replications were taken and the dimensions *viz*., l, w and t were measured at three major axes. Each seed size in terms of equivalent diameter (D_e) was also analyzed by using following formula (Mohsenin, 1970).

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

Where,

D_e = equivalent diameter of cotton seed, mm
l = length of cotton seed, mm
w = width of cotton seed, mm
t = thickness of cotton seed, mm

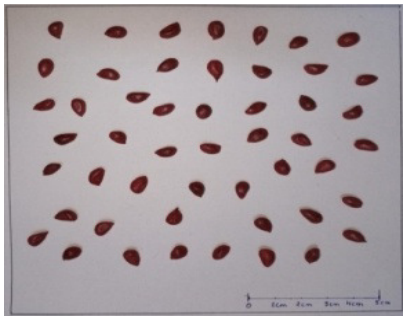
Fig. 1. Measurement of size using vernier caliper.

ImageJ. ImageJ software is a very rapid, reliable method to find out the size and shape of the irregular seeds and other objects and its accuracy is very high so by using this software not only time can be saved but also accurate results can be obtained and also large number of seeds can be handled at a time to determine

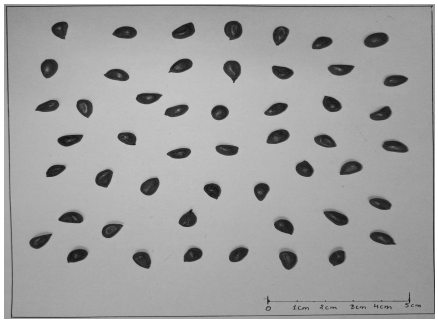
geometrical properties and linear of irregular seeds (Ramesh *et al*., 2015). This technique mainly require image acquisition device like camera or scanner and analysis software (ImageJ).

A 64 M.P. camera was used to capture the seed images. The cotton seeds were randomly scattered on the white sheet paper (150 mm × 150 mm) and 50 mm line was drawn on the paper to take reference during the image processing. The image was captured as shown in Fig. 2a and the pixel of image was 1258 × 1280 pixels. The seeds should not be placed very close or in touch with each other. The shade effect of seeds should be eliminated. The image was imported from phone to Laptop and ImageJ software was used to analyse the image. By using type section tool in the ImageJ software, the colored image was transformed into binary image (Fig. 2b). The configuration of the scale, which transforms the pixel value into the desired measurement units, is a crucial step in measuring the seed dimension.

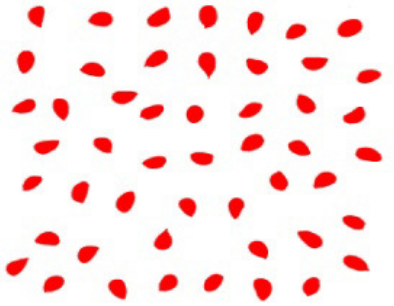
In the image menu, click on adjust to go on threshold bar. Clicking threshold icon the image of seeds was selected or identified (Fig. 2c). The edges of the cotton seeds were finalized using the edge command (Fig. 2d). The seeds are separated by its background. In the analyze menu, the desire size needed was selected by using analyzed particle because by default it will show zero to infinity, so its value should be change as it will select all dimension between this range and show huge error (Ramesh *et al*., 2015). The flowchart of procedure for measurement of seed size by digital image analysis is shown in Fig. 3.



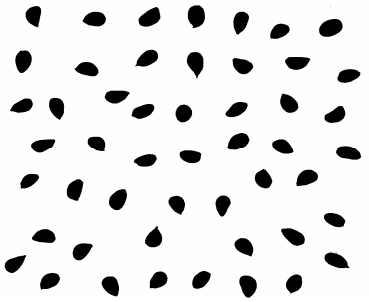
(a) Cotton seed image captured by mobile camera.



(b) Bit Image.



(c) Threshold Image.



(d) Edge Detection.

Fig. 2. Determination of size of seed image using image analysis method.

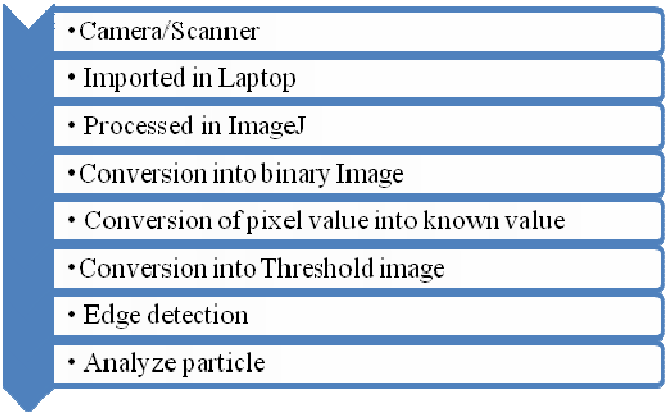


Fig. 3. Flowchart for procedure for measurement of size by digital image analysis.

Sphericity (Φ). Sphericity is the indirect measurement of selected seeds in terms of closeness to the sphere. It is defined as the ratio of surface area of a sphere with the same volume as the seed of the surface area of the seed. The uniform free flow of cotton seed from the cell surface in uniform manner was described by the sphericity property. The sphericity of the cotton seed was calculated by using following equation (Mohsenin, 1970).

$$\Phi = \frac{(l \times w \times t)^{1/3}}{l}$$

Moisture content. Moisture content of hybrid cotton seeds were determined by using oven dry method (Fig. 4). Three sample of hybrid cotton seed each having weight of 5 gram was placed in container and weighed on digital weighing balance. The three samples after weighing were kept in the dry oven machine at 103°C for 17 hours (Anon., 2022). After 17 hours the seed samples were removed and cooled in desiccators. The dried hybrid cotton seeds again weighed on the weighing balance. The moisture content of seeds was calculated by using following equations (Sahay and Singh 1994)

$$M.C. = \frac{W_i - W_d}{W_i} \times 100$$

Where, M.C. = moisture content, (w.b.) %
W_i = initial weight of sample, g
W_d = dried weight of sample, g

Bulk density. Bulk density of the hybrid cotton seeds is weight of seeds per unit volume. Seed samples having weight of 125 g were placed in cylindrical steel box which was having diameter of 8.33 cm with height of 3.89 cm (Fig. 5). Bulk density was calculated as ratio of weight of seed in container to volume of the container and expressed as kg m^{-3} (Mohsenin, 1970).

True density. True density of hybrid cotton seed was analyzed by toluene displacement method (Fig. 6). The toluene was poured up to the level of 15 ml and 5 gram of seed was placed into the beaker. After placing cotton seeds, increase in toluene level was noted. The increased level of toluene is equal to is the displaced toluene volume (Mohsenin, 1970).

Hundred seed weight. 5 sample of 100 seeds of hybrid cotton taken in a box and weighted on an electronic balance with sensitivity of 0.001 gram.

Angle of repose. The angle of repose determines the flow ability of seeds. The angle of repose was determined by placing the seeds in a conical container (Fig. 8). The conical container at a height has opening at the bottom and slowly open the opening at bottom, so that the seeds fall from a certain known height on a circular disc of diameter 13 cm to facilitate formation of heap and then the heap's height formed on the circular disk was noted. The angle of repose was determined by using following equation (Mohsenin, 1970).

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

Where, θ = Angle of repose, degree
h_0 = Heap's height, m
r = Heap's radius, m

Coefficient of friction. Standard apparatus of MS sheet was used to calculate the coefficient of friction. The known amount of hybrid cotton seeds were filled in wooden container attached to string at one end placed on the MS sheet and at another end of string loading plate was attached which was hanging down the MS sheet. The weight were added on the loading plate until the filled wooden container start moving from its place due to downward moment of the loading plate (Fig. 9). The procedure was repeated for three different samples. The following equation was used to calculate the coefficient of friction of hybrid cotton seeds (Mohsenin, 1970).

$$\mu = \frac{F}{N}$$

Where, μ = Coefficient of friction
F = Frictional force (force applied)
N = Normal friction (weight of the grain)

Fig. 4. Measurement of moisture content of cotton seeds using hot air oven.

Fig. 5. Measurement of bulk density.

Fig. 6. Measurement of true density by toluene displacement.

Fig. 7. Measurement of hundred seed weight of cotton seeds.

Fig. 8. Measurement of angle of repose of cotton seeds.

Fig. 9. Measurement of coefficient of friction of cotton seeds.

RESULTS AND DISCUSSION

Other engineering properties of cottons seeds *viz.*, size, shape spehericity, moisture content, true density, bulk density, hundred seeds weight, angle of repose and coefficient of friction were determined by standard procedure as explained above. The results of engineering properties have been summarized below:

Seed size. In the conventional method, average length of the hybrid cotton seeds measured was 8.55 mm with standard deviation (std. dev.) of 0.56 using vernier caliper, where as in digital image analysis method the average length of cotton seeds measured was 8.70 mm with std. dev. of 0.60 (Table 2). The length of cotton seeds varied between 7.15 to 10.29 mm when measured with vernier calipers whereas using digital image analysis method, the length of cotton seeds varied from 7.4 to 9.9 mm. The width of cotton seeds measured using vernier caliper ranged from 4.17 to 6.17 mm and by using digital image analysis method it ranged from 4.62 to 6.74 mm. The average width of the cotton seeds was measured 5.33 mm with std. dev. of 0.37 using vernier caliper. Whereas with use of digital image analysis method, it was measured 5.63 mm with std. dev. of 0.40 (Table 2). The thickness of the hybrid cotton seeds varied between 4.12 to 5.63 mm. The average thickness of the hybrid cotton seeds was 4.88 mm with std. dev. of 0.33 (Table 2). The mean equivalent diameter (D_e) of hybrid cotton seeds measured using vernier caliper was 6.04 mm (Table 2) and varied between 5.15 to 6.14 mm. The mean equivalent diameter (D_e) of cotton seeds using digital image analysis technique was found 6.19 mm and varied between 5.64 to 6.76 mm.

The size distribution of cotton seeds for length while using vernier calipers was found to be 14, 66, 18 and 2 % for seeds length between 7-8, 8-9, 9-10 mm and

more than 10 mm, respectively and while using digital image analysis technique, the size distribution of length was 12, 48 and 40 % for the length between 7-8, 8-9 and 9-10 mm (Fig. 10). The size distribution of cotton seeds for width while using vernier calipers was 12, 84 and 4 % seeds width was between 4-5, 5-6 and 6-7 mm while using digital image analysis technique, the size distribution of width was 16, 76 and 18 % for the width between 4-5, 5-6 and 6-7 mm, respectively.

In the results it was found that there exist strong correlation between conventional method and digital image analysis technique and followed a linear relationship with correlation coefficient (r) and regression coefficient (R^2) of 0.96 and 0.93 for length and 0.982 and 0.964 for width of hybrid cotton seed (Table 1). The regression coefficient (R^2) obtained in this study was higher than that reported by Ramesh *et al*. (2015) for three cotton seed varieties. These findings indicated that there is a high potential for using a digital image analysis technique for measuring small seed dimensions, which is a nondestructive and time-saving method. The largest cotton size value in terms of length and width was used to determine the size of cell of seed metering plate of the planter.

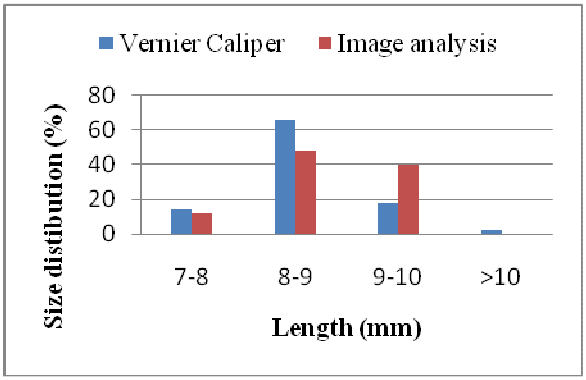


Fig. 10. Size distribution of cotton seed at different lengths.

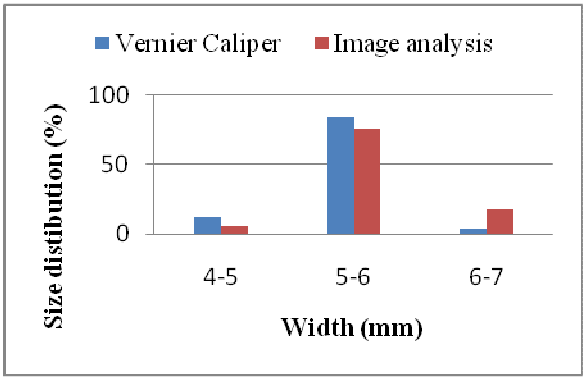


Fig. 11. Size distribution of cotton seed at different widths.

Table 1: The relationship between convention method (Y, mm) and image analysis data (X, mm) determined for length and width of cotton seeds.

Seed Length	
r	0.96
R^2	0.93
Equation	Y = 0.900X + 0.663
Seed Width	
r	0.98
R^2	0.96
Equation	Y = 0.909X + 0.215

Sphericity. The spehericity of cotton seeds was examined using vernier caliper and image analysis method. The average spehericity of cotton seeds using vernier calipers was 0.7 whereas using digital image analysis method, it was also 0.7. The spehericity of cotton seeds using vernier varied between 0.62 to 0.84, whereas using digital image analysis method was varied between 0.64 to 0.77. The average value of spehericity for cotton seeds for both the method *i.e.* conventional method and digital image analysis method was slightly higher than value as reported by Ramesh *et al.* (2015) for the three hybrid variety of cotton seeds. The non spherical seeds movement is slower under gravity. In this study, the spehericity of cottons seed obtained was found hemispherical shape.

Moisture content. In order to achieve better planting performance and favorable germination, moisture content of cotton seeds should be optimum. The moisture content of selected hybrid cotton seeds was varied between 7.97 to 8.35 % (w.b.) with an average value of 8.15 % (w.b.). The moisture content was determined before the sowing operation to check whether the seeds are favorable for sowing operations.

Bulk density. Bulk density of the seeds is expressed as weight of uncompacted seed mass per unit volume. The bulk density of cotton seeds ranged from 586 to 591 kg m^{-3} with an average 588 kg m^{-3}. The average value of bulk density for cotton seeds was very close to the value reported by Ramesh *et al*. (2015) for the three hybrid variety of cotton seeds. The bulk density was used to determine the capacity of the seed box in term of volume of the microcontroller based precision planter.

True density. The true density of cotton seeds varied from 1000 to 1008 kg m^{-3} with an average 1005 kg m^{-3}. The results obtained in the study were close to the value reported by Ozarslan (2002).

Hundred seed weight. Electronic weighing balance with sensitivity of 0.001 g was used to examine hundred seed weight of cotton seeds. The weight of hundred cotton seeds varied between 10.43 to 10.9 g. The average weight of hundred cotton seeds was 10.63 g. The hundred seed weight was used to determine the seed rate of cotton sowing by the developed microcontroller based precision planter.

Angle of repose. Angle of repose determines the flow ability of the seeds through seed box and the seed tube. The angle of inclination of seed metering plate in inclined seed metering plate will be determine by the value of angle of repose of the seed and the seed

metering mechanism will operate smoothly if angle of inclination of seed metering plate value will be close to angle of repose. There will be multiple seed dropping if value of angle of inclination will be less than angle of repose and if value of angle of inclination will be more than angle of repose then the seed will be miss from planter during sowing operation. The angle of repose varied between the range of 35.26° to 37.95° with an average 36.9°. The mean value of angle of repose for cotton seeds was very close to the value reported by Ramesh *et al.* (2015) for the three hybrid variety of cotton seeds. The angle of repose is an important parameter which is responsible for the performance of planter. The value of the angle of repose was used to set the inclination angle of the seed plate and the seed box frame and in the research 40° as a optimum angle was choosen for angle of inclination of seed metering plate of microcontroller based precision planter.

Coefficient of friction. The coefficient of friction between the M.S. sheet material and the selected cotton seeds was determined. The average coefficient of friction was 0.55. The coefficient of friction of cotton seeds varied from 0.46 to 0.65. The results obtained in the study were close to the value reported by Vinayaka *et al.* (2020).

Table 2: Engineering properties of Cotton.

Sr. No.	Properties	Values
1	Variety	SRCH BG-II
2	Size	
(i)	Vernier calipers	
	Length, mm	8.55 ± 0.56
	Width, mm	5.33 ± 0.37
	Thickness, mm	4.80 ± 0.33
	Equivalent diameter (D_e), mm	6.04
(ii)	Image analysis technique	
	Length, mm	8.76 ± 0.60
	Width, mm	5.63 ± 0.40
	Equivalent Diameter (D_e)	6.19
3	Sphericity	
(i)	Vernier calipers	0.70
(ii)	Image analysis technique	0.70
4	Moisture content, % (w.b.)	8.15
5	Bulk density, kg m^{-3}	588
6	True density, kg m^{-3}	1005
7	Hundred seed weights, g	10.63
8	Angle of repose, deg	36.9°
7	Coefficient of friction	0.55

CONCLUSIONS

In the study strong correlation was found between traditional vernier caliper method and digital image analysis method in terms of length and width of cotton seeds. The average length and width of cotton seeds in digital image analysis was slightly higher than conventional vernier caliper method.

The mean value of length, width and thickness using vernier caliper were 8.55, 5.33 and 4.80 mm and the mean value of length and width using image analysis were 8.76 and 5.63 mm. The spehericity of the seeds was same *i.e.,* 0.70 for both the methods.

Moisture content, bulk density and true density varied between 7.97 to 8.35 per cent (d.b.), 586 to 591kg m^{-3}, 1000 to 1008 kg m^{-3}. The average weight of hundred seeds was 10.63 g.

Angle of repose was varied between 35.26° to 37.95°. Average value of coefficient of friction of mild steel was 0.55**.**

FUTURE SCOPE

The values of engineering properties of cotton seeds obtained in this research will not be only useful in future design and development of precise seed metering mechanism and planter but also will be useful in the development of other machine used for sorting, grading, storage, processing of seeds, transportation and many other applications. The digital image analysis method will be very useful for faster size and shape determination as well as if large amount of seeds has to handled at time for size and shape determination. The digital image analysis method can also be applied in other food grains, seeds and fruits etc., for size, shape and texture analysis.

Author contributions. Conceived and designed the analysis: Lalit ManoharYadav, Sushilendra, Sunil Shirwal and Vijayakumar Palled; Collected the data: Lalit Manohar Yadav, Sushilendra and Sunil Shirwal; Contributed data or analysis tools; Lalit Manohar Yadav, Sushilendra, Sunil Shirwal and Vijayakumar Palled and Ananda N; Performed the analysis: Lalit Manohar Yadav, Sushilendra, Sunil Shirwal, Hirekurubaruand Murali M; Wrote the paper: Lalit Manohar Yadav, Sushilendra and Sunil Shirwal.

Acknowledgement. I extend my sincere thanks to Assoc. Prof. (Dr.) Sushilendra (major advisor) and to my advisory committee members for giving me proper guidance

throughout the course of study. I also sincerely thank ICAR-AICRP on FYM scheme and ICAR for supporting the research financially by awarding me National talent Scheme. This paper is a part of the M. Tech. research of the first author registered at University of Agricultural Sciences, Raichur (Karnataka) and thesis major work carried at Dept. of Farm Machinery and Power Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur. The facilities provided by the H.O.D. (Dept of FMPE & PFE), CAE, UAS, Raichur, for carrying out this study are acknowledged.

Conflict of Interest. None.

REFERENCES

Aydogdu, M. H., Sevinç, M. R. and Cançelik, M. (2021). A research on the perceptions of cotton producers to form a producers' union in Şanlıurfa-Turkey. *Journal of Ekonomi, 3*(1), 5-8.

Ercisli, S., Sayinci, B., Kara, M., Yildiz, C. and Ozturk, I. (2012). Determination of size and shape features of walnut (*Juglans regia* L.) cultivars using image processing. *Scientia horticulturae*, *133*, 47-55.

Fıratlıgil-Durmuş, E., Šárka, E., Bubník, Z., Schejbal, M. and Kadlec, P. (2010). Size properties of legume seeds of different varieties using image analysis. *Journal of Food Engineering*, *99*(4), 445-451.

Hsieh, H. M., Swanson, B. G., Lumpkin, T. A. (1998). Azuki bean sizes and ama-natto preparation. *Food Research International, 31*, 629–634.

Igathinathane, C., Chattopadhyay, P. K. (1998). Numerical techniques for estimating the surface areas of ellipsoids representing food materials. *Journal of Agricultural Engineering Research*, *70*, 313–322.

Kadlec, P., Skulinova, M., Sarka, E. and Fort, I. (2006). Microwave and vacuum microwave drying of germinated pea seeds. *In: Proceedings of 17th International Congress of Chemical and Process Engineering CHISA (CD ROM), Prague, Czech Republic*.

Lurstwut, B. and Pornpanomchai, C. (2017). Image analysis based on color, shape and texture for rice seed (*Oryza sativa* L.) germination evaluation. *Agriculture and Natural Resources, 51*(5), 383–389.

Maheshwari, C. V. (2013). Quality Assessment of *Oryza Sativa* Ssp Indica (Rice) Using Computer Vision. *International Journal of Innovative Research in Computer and Communication Engineering, 1*(4), 1107–1115.

Mohsenin, N. N. (1970). Physical Properties of Plant and Animal Materials (2nd edn.). *Gordon and Breach Science Publications*, New York, USA.

Nurcahyani, A. A. and Saptono, R. (2015). Identifikasi kualitas beras dengan citra digital. *Scientific Journal of Informatics*, *2*(1), 63–72.

Ozarslan, C. (2002). PH-Postharvest Technology - Physical Properties of Cotton Seed. *Biosystem Engineering*, *2*(83), 169-174.

Ramesh, B., Reddy, B. S., Veerangoud, M., Anantachar, M., Sharanagouda, H. and Shanwad, U. K. (2015). Properties of cotton seed in relation to design of a pneumatic seed metering device. *Indian J. Dryland Agric. Res. & Dev.*, *30*(1), 69-76.

Sahay, K. M. and Singh, K. K. (1994). *Unit operations of agricultural processing*. Vikas Publishing House Pvt. Ltd..

Soni, R. and Rajput, A. S. (2018). Prospects, aspects and scope of organic farming in cotton cultivation in India. *Compendium of Lead and Invited Papers*, 435.

Tanska, M., Rotkiewicz, D., Kozirok, W. and Konopka, I. (2005). Measurement of the geometrical features and surface color of rapeseeds using digital image analysis. *Food Research International*, *38*(7), 741-750.

Vinayaka, M. V., Sushilendra, D. M., B. K. D. and Doddagoudar, S. R. (2020). Study on some engineering properties of cotton seeds in relation to the development of a tractor operated seed dibbler. *Journal of Pharmacognosy and Phytochemistry*, *9*(5), 1836-1839.

Widiastuti, M. L., Hairmansis, A., Palupi, E. R. and Ilyas, S. (2018). Digital image analysis using flatbed scanning system for purity testing of rice seed and confirmation by grow out test.

Williams, K., Munkvold, J. and Sorrells, M. (2013). Comparison of digital image analysis using elliptic Fourier descriptors and major dimensions to phenotype seed shape in hexaploid wheat (*Triticum aestivum* L.). *Euphytica*, *190*, 99-116.

How to cite this article: Lalit Manohar Yadav, Sushilendra, Sunil Shirwal, Vijayakumar Palled, Ananda N., Mareappa Hirekurubaru and Murali M. (2023). Determination of Engineering properties of Cotton Seeds for the Development of Microcontroller based Precision Planter. *Biological Forum – An International Journal, 15*(4): 56-63.