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ESTIMATION OF SOME PHYSICAL AND MECHANICAL CHARACTERISTICS OF WHEAT GRAIN AT DEFINITE MOISTURE CONTENT

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Abstract: Physical properties and mechanical properties of grains have importance in design of farm machinery, processing equipment's, handling equipment's, and processing of food and agricultural products. The physical properties must be known to an engineer to design a machine for handling, cleaning, conveying, storing and milling. There are some of important physical properties such as shape, size, volume, density and mechanical properties like angle of repose, static friction coefficient of different grains is necessary for the design of seed drill cum fertilizer, harvester, thresher etc. and food processing units such as separating, handling, storing, drying systems etc. Physical and mechanical properties of grain were estimated at Food Research Lab, Food and Processing Engineering, Vaugh Institute of Agricultural Engineering and Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, (Uttar Pradesh). Therefore,

The objective of present study was to determine some physical and mechanical properties of wheat grain at 9.2 % moisture content such as dimensions (length, width and thickness); equivalent, geometric and arithmetic mean diameter; sphericity; surface area; area of flat and transverse surface; volume; mass of one grain; and then other properties under effect of moisture content variation such as density, thousand kernel mass, coefficient of friction against deferent materials and angle of repose.

The average length, width and thickness of wheat seed were measured 6.25, 4.48 and 3.73 mm at a moisture content of 9.7 % (wet basis) respectively.

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Equivalent diameter and sphericity were calculated at moisture content of 9.7 % were 4.63 mm and 74 %. The bulk density and particle density was estimated 623 and 1215 kg/m^3 at same moisture content while mechanical properties such as angle of repose and static friction were determined 24.6^0 and 0.352 respectively at same moisture level. Therefore, these estimated physical and mechanical properties can be used to design and development of combine tillage and sowing assembly.

***Key words**: Physical properties, Mechanical properties, Wheat*

INTRODUCTION

Physical properties and mechanical properties of grains vital role in the design of farm machines, structures, processing equipment, handling equipment, processing of food and agricultural products. The estimation of some important physical properties such as shape, size, volume, density and mechanical properties like angle of repose, static friction coefficient of different grains is necessary for the design of various separating, handling, storing and drying systems [7]. These physical and mechanical properties are significantly affected by numerous factors such as size, form, superficial characteristics and moisture content of the grain [3]**.**

Wheat is the main cereal crop in India. The total area under the crop is about 29.8 million hectares in the country and become second largest producer of wheat in the world, producing 109.6 million tonnes annually. In recent year 2023, India produced a record 112.74 million metric tons of wheat, up from 107.7 million metric tons in 2022. However, India consumes around 108 million metric tons of wheat annually.

To meet up with domestic requirements, India will need to increase wheat production to 140 million tons by 2050. The major increase in the productivity of wheat has been observed in the states of Haryana, Punjab and Uttar Pradesh. Wheat is mainly preferred for making bread; durum wheat is preferred for making the various types of pasta, while soft red winter wheat and soft white wheat are preferred to making the biscuits and cakes.

MATERIAL AND METHODS

The combined tillage and sowing machinery were designed and developed at Farm Machinery and Power Engineering, Vaugh Institute of Agricultural Engineering and Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, (Uttar Pradesh).

Combined tillage and sowing machinery are also named as vertical rotary plough with seed cum fertilizer drill has rotating sharp tines mounted on a vertical shaft and can be attached to the three-point linkage of 18-20 HP tractors. It is powered by PTO and provided with setting of different working depth adjustment. It has two flanges spaced apart some distance and each flange carries two sharp blades.

The physical and mechanical properties of wheat grain are estimated in food research lab located in university campus. These estimated physical and mechanical properties are mainly used to design and development of combine tillage and sowing assembly.

The study view of tillage and sowing machinery and other grain properties estimation in food research lab presented in Fig. 1, 2, 3, 4 respectively.

Fig. 1 Study view of combine tillage and sowing machinery

Fig. 2 Measurement of moisture content of wheat seed grain sample by oven dry method

Fig. 3. Measurement of bulk density of wheat seed grain sample by measuring cylinder

Fig. 4. Measurement of equivalent diameter and sphericity of wheat seed grain by calliper

Selection of Wheat Seed Variety

The wheat seed variety namely HUW-234 is one of popular and still being cultivated on a larger area because of its wide adaptability in adverse situations, excellent chapatti making quality and suitability for rainfed cultivation. The wheat variety HUW-234 (popularly known as Malviya 234) was developed by the Breeding Department of Agriculture and provides an average yield of 31-35 Qtls/ha. This variety normally matures in 126-134 days, contains 10-11 percent protein with good chapatti making quality.

HUW-234 is very famous variety with significant existence in release of several improved wheat varieties among farmers of eastern Uttar Pradesh and grown by them. The main reasons for large success and popularity of HUW-234 among farmers include its adaptation to low resource environment, ability to perform better under abiotic stresses of terminal heat, limited irrigation and variable fertilizer doses and its suitability for planting even after early potato harvesting. Therefore, its suitability in all adverse conditions makes HUW-234 popular amongst farmers. Hence, viewing aspects of multi functionality of this variety, HUW-234 was selected for testing combined tillage and sowing machine during field experiment.

Equivalent diameter

Equivalent diameter can be considered by taking random samples of one hundred wheat seeds were taken out from each level of moisture content. The three major dimensions length (L), breadth (B), and thickness (T) of each seed in the sample were measured using the vernear caliber with accuracy 0.01 mm. The equivalent diameter (De) of seed was calculated by using the following relations given as follow in equation [7].

$$De = (L \times B \times T)^{\frac{1}{3}}$$

Where,

D_e = Equivalent diameter, mm
L = Length of seed sample, mm
B = Breadth of seed sample, mm
T = Thickness of seed sample, mm

Spehericity

Randomly samples of one hundred seeds were taken out for each level of moisture content. The three major dimensions length (L), breadth (B), and thickness (T) of each seed in the sample were measured using the vernear caliber with accuracy 0.01 mm. The sphericity (S) of seed were determined in term of equivalent diameter (De) by using the following relations [7].

$$\mathbf{S = \frac{De}{L}}$$

Where, D_e = Equivalent diameter, mm
L = Length of seed sample, mm

Bulk density

The bulk density was determined by filling a graduated cylinder of 500 ml with the seeds from a height of 15cm at constant rate, and the base of the cylinder was tapped a dozen times on a table [4]. Then, the cylinder was refilled again to its maximum reading (500 ml), the sample was weighed and bulk density was calculated. Each test was done in five replicates.

$$B = \frac{W}{V}$$

Where, B_d = Bulk density of seed sample, kg/m^3
W = Weight of seed sample, kg
V = Volume of seed sample, m^3

Particle density

The particle density was estimated by measuring the actual volume of a known weight of a random seeds sample. The actual volume of the seeds was determined using the toluene displacement method [6]. The particle density for each wheat seeds at each level of moisture content was repeated five times for attending accuracy.

$$\mathbf{P_d = \frac{W}{V_s}}$$

Where, P_d = Particle density of seed sample, kg/m^3
W = Weight of seed sample, kg
V_s = Displaced volume of toluene, m^3

Angle of repose

The angle of repose of the wheat grains was measured using the apparatus developed by [9] and fabricated locally. The dynamic angle of repose was the measured angle between the horizontal and the natural slope of the seeds heap. The height of the heap was measured and the dynamic angle of repose was calculated by the following relationship.

$$\boldsymbol{\theta = \tan^{-1}\left(\frac{2H}{D_p}\right)}$$

Where,
θ = dynamic angle of repose, θ^0
H = heap height of seed, mm
Dp = platform diameter, mm

Static friction coefficient

A static friction coefficient measuring apparatus as described by [8] was designed and fabricated as shown in figure (2) with the box dimensions 26 x 21 x 9 cm to measure the angle of static friction for grains at each moisture content level of wheat varieties on four different material surfaces namely plywood sheet, galvanized iron sheet, stainless steel sheet and rubber sheet.

The angle of inclination (α) was recorded and the static coefficient of friction (μ) was calculated by the following equation. The angle of friction (α) was measured ten times for each selected materials, each level of moisture content and for each wheat varieties.

$$\mu = \tan \alpha$$

Where, μ = Coefficient of friction,

α. = Angle of inclination, θ^0

RESULTS AND DISCUSSION

Estimation of wheat seed physical properties

The wheat seed physical properties were revealed in terms of average seed length, width and thickness, were measured by calipers 6.25, 4.48 and 3.73 mm at a moisture content of 9.7 % (wet basis) respectively. The equivalent diameter and sphericity was calculated on the basis of seed length, breath and thickness at a moisture content of 9.7 % were 4.63 mm and 74 %. The bulk density and particle density was estimated 623 and 1215 kg/m^3 at same moisture content. Mechanical properties such as angle of repose and static friction were determined 24.6^0 and 0.352 respectively at same moisture level.

Table 1. Estimation of various wheat seed physical and mechanical properties

Sr. No.	Seed physical properties	Moisture content (wb), %	Average length, mm	Average breath, mm	Average thickness, mm	Value
1.	Equivalent Diameter, mm	9.7	6.25	4.48	3.73	4.63
2.	Sphericity, %	9.7	6.25	4.48	3.73	74
3.	Bulk density, kg/m^3	9.7	6.25	4.48	3.73	623
4.	Particle density, kg/m^3	9.7	6.25	4.48	3.73	1215
5.	Angle of repose, θ^0	9.7	6.25	4.48	3.73	24.6
6.	Static friction coefficient, c	9.7	6.25	4.48	3.73	0.352

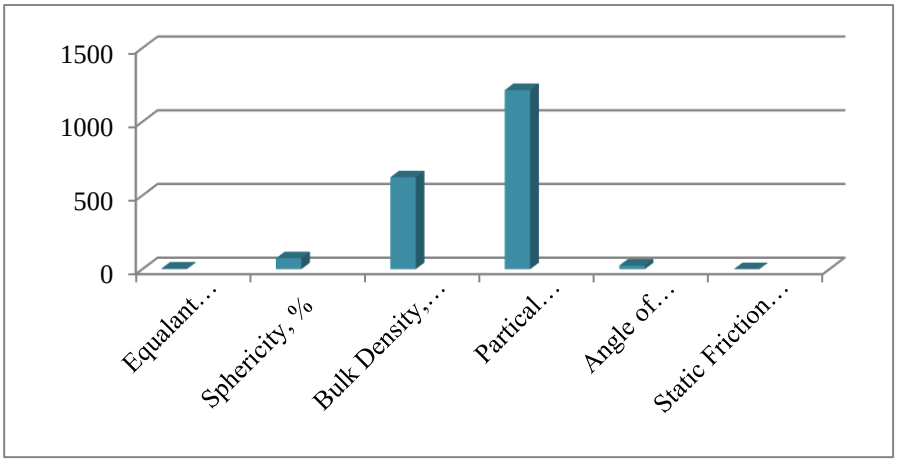

Fig. 5. Variation of the physical and mechanical properties

CONCLUSION

The average length, width and thickness of wheat seed were measured 6.25, 4.48 and 3.73 mm at a moisture content of 9.7 % (wet basis) respectively. Equivalent diameter and sphericity was calculated at moisture content of 9.7 % were 4.63 mm and 74 %.
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REFERENCES

[1] ASAE.1992. Standard, S352.2, Moisture measurement-unground grain and seeds. St. Joseph: American Society of Agricultural Engineering.
[2] Bulent Coskun, M., I., Yalcın, C., Ozarslan 2005. Physical properties of sweet corn seed (Zea mays saccharata Sturt.). *Journal of Food.Engineering*, 7(4): pp.523–528.

[3] Baumler E., Cuniberti A., Nolasco S. M. and Riceobene I. C. 2005. Moisture dependent physical and compression properties of Safflower seeds. *Journal of Food Engineering*, WWW.elsavier.Com./located/j food engineering, pp.1-7.
[4] Boumans G.1985. Grain handling and storage. Elsevier Science Publishers. B. V. Amsterdam, Belgium.
[5] Cakmak, B., Aykas, E., Onal, I. and Cakir, E. 2010. The performance of developed rotary tiller fitted with pneumatic seeder. *Bulgarian journal of agricultural science*, 16(6): pp.801- 810.
[6] Matouk A. M., Radwan S. M., Kholy M.M. and Ewies T. R. 2004. Determination of grains density and porosity for some cereal Crops. *Misr Journal of Agricultural Engineering*. 21(3): pp. 623-641.
[7] Sahay, K. M. and Singh, K. K.1994. Unit Operations of Agricultural Processing. 1st edition Vikas Publishing House Pvt. Ltd. New Delhi, India.
[8] Soliman, N. S. and Korayem, A. Y. 1983. Effect of Moisture Content of Rough Rice on its Physical Properties. Agrisci. & Dev. Res. 5: pp.103-117.
[9] Soliman N.S.1994. Effect of moisture content on angle of repose of Paddy rice and its products. *Journal of Agricultural Engineering*, 11(1): pp.163-173.

PROCENA NEKIH FIZIČKO-MEHANIČKIH KARAKTERISTIKA PŠENIČNOG ZRNA KOD ODREĐENOG SADRŽAJA VLAGE

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Apstrakt: Fizičke i mehaničke osobine žitarica imaju značaj u projektovanju poljoprivrednih mašina, opreme za preradu, opreme za rukovanje i preradu hrane i poljoprivrednih proizvoda. Fizička svojstva moraju biti poznata inženjeru da bi dizajnirao mašinu za rukovanje, čišćenje, transport, skladištenje i mlevenje.
Postoje neke važne fizičke osobine kao što su oblik, veličina, zapremina, gustina i mehanička svojstva, ugao mirovanja, koeficijent statičkog trenja različitih zrna neophodnih za projektovanje sejalice za đubrivo, kombajna, vršilice itd. i jedinica za preradu hrane kao što su odvajanje, rukovanje, skladištenje, sistemi za sušenje itd.
Fizička i mehanička svojstva zrna su procenjena u laboratoriji za istraživanje hrane, Inženjering za hranu i preradu, Vaugh Institute of Agricultural Engineering and Technologi, Sam Higginbottom Univerzitet za poljoprivredu, tehnologiju i nauku, Praiagraj, (Uttar Pradesh). Zato je cilj ovog istraživanja bio da se utvrde neke fizičko-mehaničke osobine pšeničnog zrna pri sadržaju vlage 9,2% kao što su: dimenzije (dužina, širina i debljina); ekvivalentni, geometrijski i srednji aritmetički prečnik; sferičnost; površina; površina horizontalnog i poprečnog preseka zrna; zapremina; masa jednog zrna; a zatim i druga svojstva pod uticajem varijacije sadržaja vlage kao što su gustina, masa hiljadu zrna, koeficijent trenja u odnosu na različite materijale i ugao mirovanja.

Prosečna dužina, širina i debljina zrna pšenice izmerene su 6,25, 4,48 i 3,73 mm pri sadržaju vlage od 9,7 % (mokra osnova). Ekvivalentni prečnik i sferičnost su izračunati pri sadržaju vlage od 9,7 % i iznosili su 4,63 mm i 74 %. Zapreminska gustina i gustina zrna procenjena je na 623 i 1215 kg/m^3 pri istom sadržaju vlage. Mehanička svojstva kao što su ugao mirovanja i statičko trenje utvrđena na 24,60 odnosno 0,352 pri istom nivou vlage. Zbog toga se ove procenjene fizičko-mehaničke osobine mogu koristiti za projektovanje i razvoj kombinovanih mašina za obradu zemljišta i setvu.

Ključne reči: *Fizička svojstva, mehanička svojstva, pšenica*.

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