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STUDY ON PHYSICAL AND ENGINEERING PROPERTIES FOR GRAINS OF SOME FIELD CROPS

El Fawal ,Y.A. * ; M.A. Tawfik ** and A.M. El Shal **

ABSTRACT

The present study aimed to determine and recognize a database of physical and engineering properties of grains of some main and popular feed, industrial crops which play an important role in designing and developing of specific machines and their operations such as planting, harvesting and grading .The studied crops namely fennel flower, rice (Giza101), rice (Giza 177), broad bean, corn (hyb. 310), corn (hyb. 352), wheat (Giza9) and wheat (Giza 168)and their selection based on their recent coverage area and the expected future expansion of each variety. Various physical properties including grain dimensions (length, width and thickness), the weight of thousand grain, bulk density, percent of sphericity, projected area , and the mechanical properties including angle of repose and coefficient of friction, in addition to the aerodynamic properties including terminal velocity, drag coefficient and Reynold's number, were determined at storage moisture content 7–12%(wb).The obtained data showed that it is recommended to use the stainless steel or galvanized iron in manufacturing of seed hopper used in planting machines, silos and storage containers with sides inclination of 40° to allow an easily sliding for the studied grains.. The physical properties of seed play an important role to select the proper separating and cleaning equipment and the main dimensions are considered in selecting and designing the suitable size of the screen perforations. Also, the average terminal velocities of grains were 4.17, 7.32, 7.02, 20.16, 15.34, 14.69, 8.00 and 7.58 m/s for fennel flower, rice (Giza101), rice (Giza 177), broad bean, corn (hyb. 310), corn (hyb. 352), wheat (Giza9) and wheat (Giza 168) respectively. Reynold's number of the terminal velocities of the studied grains exceeds the critical velocity of Reynold's number (R_N=2100) in the range of turbulent flow except the fennel flower seeds.

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* Researcher, Agric. Eng. Res. Inst., Giza, Egypt.
** Lecturer, Agric. Eng. Dept. Fac. of Agric., Zagazig Univ., Egypt.

INTRODUCTION

Identifying the physical and engineering characteristics of cereal crop grains is very important to optimize the design parameters of agricultural equipment used in their production ,handling and storage processes. So, it is essential to determine and recognize the database of physical and engineering (aerodynamic and mechanical) properties of these agricultural products because these properties play an important role in designing and developing of specific machines and their operations such as sorting ,separating and cleaning , also to determine the optimum in seed metering device in pneumatic planter and precision sowing machine to suite every size of these grains. Hence, this study aimed to determine the optimum values of the basic physical and engineering properties of grains of some main and popular feed crops to utilize the obtained results to optimize the best design parameters in agricultural equipment. **Klenin et. al. (1985)** mentioned that, the behavior of particles in air stream is diameter of holes in seed metering devices in planting, air suction suitable for seed holding governed by their aerodynamic properties of particles ,the critical velocity (terminal velocity) V_{cr}, resistance coefficient of the air (K_r) and drift coefficient (K_d). **Sitkei (1987)** reported that the functioning of many types of agricultural machines (sifters, sowing machines, pneumatic transport systems, etc.) is influenced by the physical properties of the objects participating, and so in order to study a given process they must be described accurately, Also the quality of processing (in chopping and milling) may be characterized by a products mean size and mean standard deviation, or these data may be used to organize a technological process or in designing certain structural elements (mesh dimensions of sifters or dimensions of screen holes).He added that during the treatment of agricultural materials air is often used the transport medium, pneumatic transport and cleaning of various agricultural products have been known for along time, during this process aerodynamic properties play an important role and must be known for optimum design and the operation of the equipment. The two most important aerodynamic properties of a body are drag coefficient and terminal velocity. **Sabbah et al. (1994)** studied the effect of moisture content on the physical properties for three Egyptian paddy rice varieties.

They recorded the increase occurring in seed sphericity (S) due to the increase of moisture content . **EL–Sahrigi (1997)** indicated that it is essential to understand the physical and engineering law governing the response of agricultural biological material, so that processing and handling machines can be designed for maximum efficiency and highest quality of the end product .**Kochhar and Hira (1997)** reported that to design equipment and facilities for handling processing and storage, the physical properties of crop grains must be known. **Lgathinathane and Hana(1998)** reported that some seeds, fruits and vegetables of spherical in shape with variation along one or both axes. In general, to specify the shape of a food material it is necessary to identify three basic dimensions, namely, length, width and thickness. A body can be defined by one or two significant dimensions only in a few special cases where the body approximates to a regular geometrical shape such as a sphere, cylinder, prolate spheroid or oblate spheroid. **Nimkar and Chattopadhyay (2001)** reported that various physical properties of green gram were evaluated as a function of moisture content in the range of 8.39 to 33.40 % d.b.. The average length, width, thickness and the mass of thousand seeds were 4.21 mm, 3.17 mm, 3.08 mm, and 28.19 g respectively at moisture content of 8.39 % (d.b.), Also, the average geometric diameter increased from 3.45 mm to 3.77 mm, whereas sphericity decreased from 0.840 to 0.815.They added that by increasing moisture content the bulk and true densities decreased from 807 to 708 kg/m^3 and 1363 to 1292 kg/m^3, respectively , whereas the corresponding bulk porosity increased from 40.77 to 45.16%. **Nonami and Nelson (2002)** conducted a study to enable easy seed and waste separation at head feed combine by measuring the terminal velocity. It was found that, it is difficult to separate seeds with primary branches and straws from a single seed in the tank because the terminal velocity of the seed with primary branches and straw was more than the single seed. The suitable limits of the separating air velocity was from 2.3 to 6.5 m/s.. **Matouk et al. (2004)** developed the mathematical relationships relating the changes of the properties with the seed moisture content. The seed principal dimensions, mass of 1000 seeds and seed projection area are generally increased by increasing of seed moisture content. However, both shape-index and coefficient of contact surface are decreased by increasing of seed moisture content. The main objectives of this study are to (1)determine the basic physical and engineering properties of some main and popular feed crops (2).investigate the relationship between these grains properties affecting the agricultural mechanization.

MATERIALS AND METHODS

To achieve the target of this experimental work, some varieties of main crops namely (wheat, rice, corn, broad bean, and fennel flower) which represent the major important food; industrial crops in Egypt, were selected based on their recent coverage area and the expected future expansion of each variety. Samples of the selected varieties of each crop were procured from the experimental farm of Gemmiza Agricultural Research Station, El–Gharbia Governorate, Egypt and cleaned from foreign matters, broken and immature grains. Random samples of 5 kg from raw grain lots were taken and used 150 of grains for varieties from each crop at storage moisture content (7–12%) to determine the optimum physical and engineering (aerodynamic and mechanical) properties.

A-Materials

The study was carried out using local varieties of some main field crops namely: wheat (Giza 9 and Giza 168), corn (hybrid 310 and hybrid 352), rice (Giza 101 and Giza 177), In addition to broad bean and fennel flower as a medical crop.

B-Instrumentation

1. Electronic digital balance

The electronic balance was made in Japan and used in this study for measuring the mass of samples. It was used in determining particles mass with an accuracy of 0.1 mg.

2. Electronic digital vernier calipar

It was used for measuring the dimensions of grains and their associated foreign matters. It was made in Japan, model METR ISO_G.The range of reading is 0.01 to 15 mm with an accuracy of 0.05 mm.

3. Digital–hydrometer–moisture content-meter

Model G–86, with an accuracy of 0.1 %. It was made in Germany and used for measuring the moisture content in percentage of the studied seeds on wet basis.

4. Anemometer

It was Tri-sense. Hygrometer/Anemometer/ Thermometer. Model No. 37000-00. Cole Parmer Instrument Company, Illinois, USA. It was used for measuring air velocity by m/s.

5. Terminal velocity apparatus

The apparatus used in this study was constructed in the workshop of Agric. Eng. Res. Inst., in Gemmiza Agricultural Research Station, El–Gharbia Governorate, Egypt. The apparatus as shown in Fig .(1) , consists of an electric blower which discharge air blast into a transparent tapered tube used as a cyclone which is fixed at the outlet side of the blower through an elbow. A screen is fitted at the bottom of the transparent tapered tube of 8×4 cm cross section and a cyclone is fitted at the top of it 15 cm square cross section. A chock valve is built at the bottom of the cyclone to control the air flow rate. The chock valve is manually adjusted by the control lever.

6. Angle of repose meter

It was used for measuring the angle between the base and the slope of the cone formed due to a free vertical fall of the seed mass.

7. Digital instrument for measuring the friction angle

It was used for measuring the friction angle and the repose angle for the studied seeds on metal-sheet surface with dimensions 14×31.5 cm. The digital measuring device designed and constructed in Meet–EL–Dieba at Kafr El-shieakh Governorate, Egypt at the laboratory of Rice Mechanization Center (RMC).

8. Graduated cylinder

It was used for measuring volume for the investigated crops seeds to obtain real and bulk density.

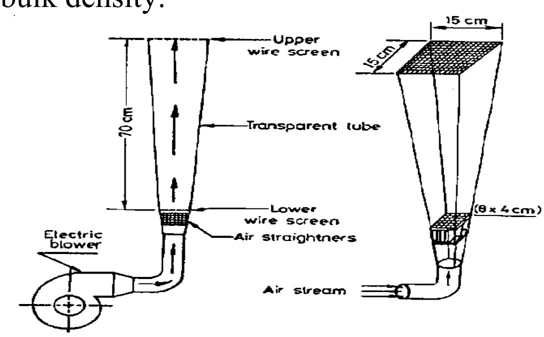

Fig.(1): Terminal velocity apparatus

2. Experimental procedures:

The main experiments were conducted to determine and calculate the physical, aerodynamic and mechanical properties of crops varieties under study. Grain dimensions (length, width and thickness), mass of thousand grain , volume, geometric diameter, arithmetic diameter, bulk and real densities, percent of sphericity, projected area, terminal velocity, drag coefficient, Reynold's number, angle of repose and coefficient of friction were measured and estimated. All the experiments were replicated five times, stated and the average values were recorded.

a– Physical properties of crop seeds varieties

Grain dimensions (L,W and T), mass of thousand grain, volume, geometric diameter, arithmetic diameter, bulk and real densities, percent of sphericity and projected area. Standard Deviation, coefficient of variation, maximum, minimum and arithmetic mean for grains varieties under studies. The calculated equations according to **EL–Raie et al. (1996)** studied that, the size of the three varieties of corn in terms of length (L), width (W) and thickness (T). The size was used to calculate the volume (V), geometric diameter (D*g*), arithmetic diameter (D*a*), percent of sphericity (S), area of surface (A*f*), and area of transverse surface (A*t*) of the individual seeds. The following equations were used to calculate the values of the above mentioned properties:

$$V = \frac{\pi}{6} LWT \quad ,mm^3$$

$$D_g = (LWT)^{1/3} \quad ,mm$$

$$D_a = \frac{(L + W + T)}{3} \quad ,mm$$

$$S = \frac{(LWT)^{1/3}}{L} \times 100 \quad ,\%$$

$$A_f = \frac{\pi}{4} LW \quad ,mm^2$$

$$A_t = \frac{\pi}{4} TW \quad ,mm^2$$

Where:

L :length of seed ,mm , W: width of seed ,mm

T : thickness of seed ,mm

$$\rho_b = \frac{m}{v}$$

Where:

ρ_b : bulk density of the grain, g/ cm^3 , m : mass of grains ,g

v : bulk volume of the grains ,g/cm^3

b– Aerodynamic properties of crop seeds varieties

The terminal velocity of crop seeds is determined by measuring the air velocities, required to suspend a seed in a vertical air stream by using terminal velocity apparatus. Drag coefficient and Reynold's number were calculated according to equations of **Hexing (1989)** as follows:

$$C_d = \frac{2gF_d}{A_p \rho_a v_t^2} \quad , \quad N_{\mathrm{Re}} = \frac{\rho_a v_t \sqrt{A_p}}{\mu}$$

Where:

V_t : terminal velocity, m/s — g : gravity, m/s^2

A_p : projected area of particle, m^2 — F_d : drag force ,N

μ : dynamic viscosity of the air,(18.10^{-6}) — C_d : drag coefficient

ρ_a : density of air, (1.28 kg/m^3)

C-Mechanical properties of crop seeds varieties

-Angle of repose

Seeds were poured under gravity from a suitable height to form a cone surface and the horizontal plan was recorded to represent repose angle of seeds using the repose angle meter.

-Friction coefficient

The seeds sample was placed over the surface to be tested, which is titled around its side pivot. The friction angle was displayed when 75% of the seeds reached the spout and the tray was stopped .Friction coefficient for the mentioned sample was obtained as follows:

$$\text{Friction coefficient} = \tan \alpha$$

Where: α = Friction angle.

RESULTS AND DISCUSSION

A random sample of about 150 seeds was taken from each crop to obtain data about some physical properties such as ,length ,width , thickness ,mass of thousand seeds, volume of seed, arithmetic diameter, geometric diameter, flat surface area, transverse area and sphericity. The measured moisture content ranged from 7 to 12 %(w.b.). The mechanical properties such as; angle of repose and coefficient of friction of some field crop grains with different types of materials are displayed in Table.(1) also, the bulk density of grains as shown in Table (3).

Table(1): Average values of dynamic angle of repose and coefficient of friction of some field crop grains with different materials

Crop	Dynamic angle of repose, degrees				
	Glass	Plywood	Galv. iron	Wood	Stain. steel
Fennel flower	11.85	18.26	20.80	26.56	13.50
Rice (Giza 101)	20.80	24.70	22.78	29.24	15.64
Rice (Giza 177)	21.30	26.56	24.70	30.11	12.40
Broad bean	19.80	17.22	21.80	23.74	19.29
Corn(hyb. 310)	21.80	20.80	22.78	30.96	23.75
Corn (hyb. 352)	20.80	19.80	22.30	29.24	22.30
Wheat (Giza9)	14.57	16.70	26.42	25.17	16.70
Wheat (Giza168)	15.64	18.79	22.30	26.10	18.26
Crop	Coefficient of friction				
	Glass	Plywood	Galv. iron	Wood	Stain. steel
Fennel flower	0.21	0.33	0.38	0.50	0.24
Rice Giza(101)	0.38	0.46	0.42	0.56	0.28
Rice Giza (177)	0.39	0.50	0.46	0.58	0.22
Broad bean	0.36	0.31	0.40	0.44	0.35
Corn (hyb. 310)	0.40	0.38	0.42	0.60	0.44
Corn(hyb. 352)	0.38	0.36	0.41	0.56	0.41
Wheat (Giza9)	0.26	0.30	0.37	0.47	0.30
Wheat (Giza168)	0.28	0.34	0.41	0.49	0.33

Table (2): Average values of static angle of repose of some field crop grains .

Crop	fennel flower	rice Giza 101	rice Giza 177	broad bean	corn hyb310	corn hyb352	wheat Giza9	wheat Giza 168
Static angle of repose (degree)	32.20	36.60	37.80	15.40	21.70	22.60	27.40	28.50

Table (3): Bulk density of some field crop grains

Crop	fennel flower	rice Giza 101	rice Giza 177	broad bean	corn hyb310	corn hyb352	wheat Giza9	wheat Giza 168
Bulk density (kg/m^3)	550	600	630	410	800	830	742	800

1.*Grain mechanical properties*

-Static angle of repose:

The represented data in Table (2) show that the values of static angle of repose were determined as 32.20, 36.60, 37.80, 15.40, 21.70, 22.60, 27.40 and 28.50 degree for fennel flower, rice (Giza101), rice (Giza 177), broad bean, corn (hyb.310), corn (hyb.352), wheat (Giza9) and wheat (Giza 168) respectively. It is clear that angle of repose of grain was decreased as the size of grain increased especially when the surface of grain becomes more smooth at storage moisture content. The previous data can be utilized to assess the optimum sides inclination of seed hopper in planting machines, silos and storage containers to allow an easily sliding.

-Coefficient of friction:

Coefficient of friction is the tangent of dynamic angle of repose. It is estimated with different types of surfaces including, glass, plywood, galvanized iron, wood and stainless steel. The obtained results in Table (1) indicate that the maximum values of coefficient of friction were obtained on the surface of wood and the minimum were obtained on the glass also, the surface of the stainless steel gives the second lowest values of coefficient of friction and it is recommended to use this material in the structure of seed hopper in planters, silos and storage containers.

2. *Grain physical properties*

-Thousand seed weight:

The average mass values of thousand seed was determined as 2.64, 26.79, 25.54, 862.46, 422.86, 302.60, 46.98, and 42.16 gm for fennel flower, rice (Giza101), rice (Giza 177), broad bean, corn (hyb.310), corn (hyb.352), wheat (Giza9) and wheat (Giza 168) respectively. Estimating the mass of seed is necessary to assess the required mass of seed for planting a limited area and number of seed in each hole.

-Bulk density:

The bulk density was determined as 550, 600, 630, 410,800, 830, 742 and 800 kg/m³ for fennel flower, rice (Giza101), rice (Giza 177), broad bean, corn (hyb.310),corn (hyb.352), wheat (Giza9) and wheat (Giza 168) respectively at storage moisture content. The bulk density is considered for determination of paging capacity, designing seed hopper dimensions in seed planters and cleaning and grading equipment.

-Grain size and shape:

The obtained data in Tables (4) to (11) show that the geometric diameter, arithmetic diameter and sphericity were determined for the studied grains and Figs. (2) to (9) display the variation of the seed three axial dimensions, length (L), width (W) and thickness (T) for fennel flower seeds, it is observed from Fig.(2) that the highest frequency distribution for(L) was 85.05% ranging from 2.5 to3mm and for(W) was 100% ranging from 1 to 1.5 mm and for (T) was74.77% ranging from 0.50 to1.00 mm, and with mean of 2.89, 1.25and 0.904 mm for (L) , (W) and (T) respectively. Figs.(3) and (4) illustrate that, for the studied varieties of rice crop(Giza 101 and Giza 177) ,the highest frequency distribution of (L),(W) and (T) for both varieties were (60-60.67%), (54-34.67%) and (60-54%) respectively. The range of grains width (W) were(3 to3.5mm) and (3.5 to 4 mm) for Giza 101 and Giza 177 respectively but both varieties have the same range of (L) (7to7.5 mm) and (T) (2 to 2.5 mm).The mean for both varieties were (7.33-7.32mm),(3.52-3.81mm) and (2.46-2.57mm) for (L) , (W) and (T) respectively. For broad bean, Fig.(5) show that the highest frequency distribution of (L) was 28% ranging from 16 to 16.50mm, for (W) was 38% ranging from13.5 to 14mm and for (T) was 22% ranging from 9 to 9.5mm with mean of 16.25, 13.75and 8.53 mm for(L) , (W) and (T) respectively. Figs.(6) and (7) show that, for the studied varieties of corn crop(hyb.310 and hyb.352) the highest frequency distribution of (T) for both varieties were (24-36%) respectively, and the same frequency of (L) (16.67%) and (W) (18%)were observed for both varieties .The range of grains length were(11 to11.5mm) and (12to12.5mm) for hyb.310 and hyb.352 respectively but width was (9 to9.5mm) for both varieties and the same range of thickness (4 to 4.50mm)was observed. The mean for both varieties were (11.74- 12.3mm), (9.13-8.24mm) and (4.37 -4.53mm) for (L), (W) and (T) respectively. It is clear that no significant differences in the three axial dimensions for both varieties. Figs.(8) and (9) illustrate that, for the studied varieties of wheat crop (Giza 9 and Giza 168) the highest frequency distribution of (L),(W) and (T) for both varieties were (64.67-64%), (36-44.67%) and (45.33-37.33%) respectively and the both varieties have the same range (6 to 6.5mm) and (3 to 3.5mm) for (L) , and (T) respectively ,while the range of (W) were (4to4.5mm) and (3 to3.5mm) for Giza9 and Giza168 respectively. The mean for both varieties were (6.35-6.25mm),(3.94-3.62mm) and (3.21-3.20 mm) for (L) , (W) and (T) respectively. Main dimensions of grain are considered in selecting, designing the suitable size of the screen perforations and determination the proper method for grading and separation.

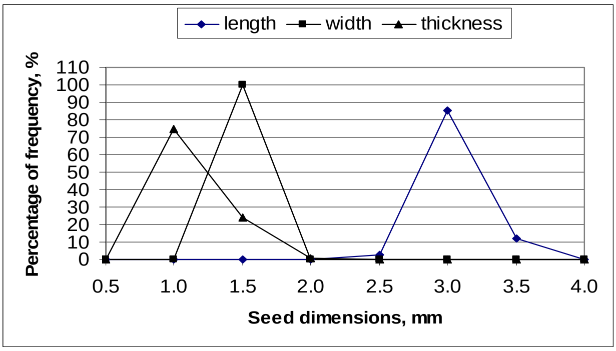

Fig.(2): Frequency distribution curves for fennel flower seed dimensions.

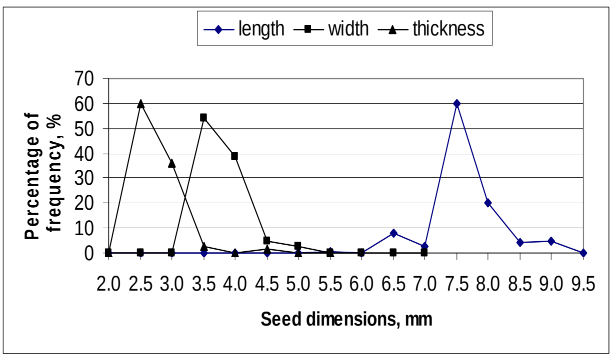

Fig. (3): Frequency distribution curves of rice (Giza101) seeds dimensions.

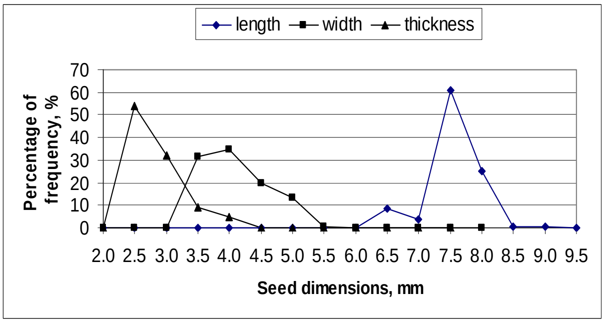

Fig. (4): Frequency distribution curves of rice (Giza177) seeds dimensions.

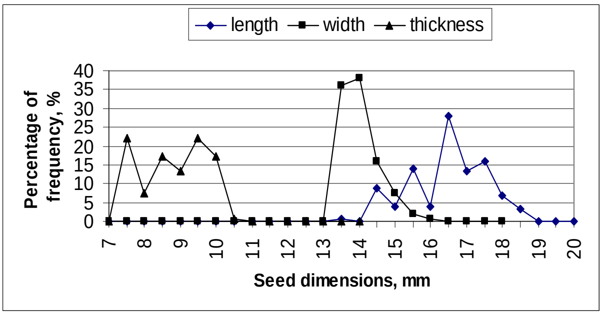

Fig. (5): Frequency distribution curves of broad bean seeds dimension

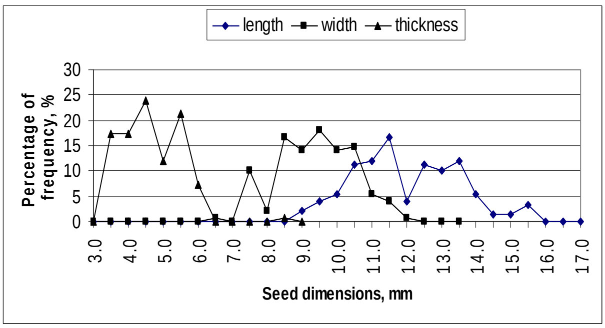

Fig. (6): Frequency distribution curves of corn (hyb. 310) seeds dimensions.

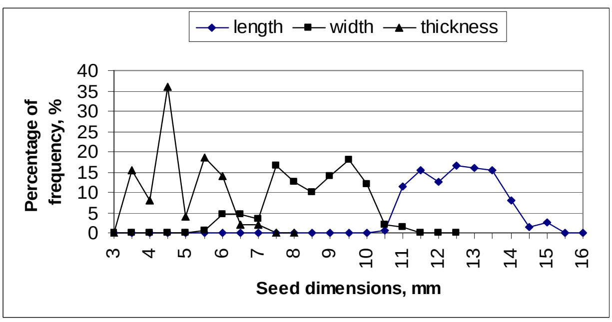

Fig. (7): Frequency distribution curves of corn (hyb. 352) seeds dimensions.

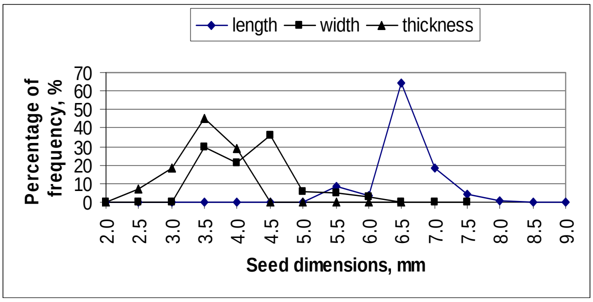

Fig. (8): Frequency distribution curves of wheat (Giza 9) seeds dimensions.

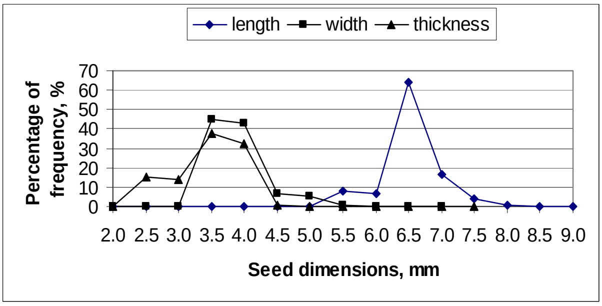

Fig. (9): Frequency distribution curves of wheat (Giza 168) seed dimensions.

3. *Grain aerodynamic properties*

-Terminal velocity:

The represented data in Tables (4) to (11) reveal that**,** the average terminal velocities for the studied grains were determined as 4.17, 7.32, 7.02, 20.16, 15.34, 14.69, 8.00 and 7.58 m/s for fennel flower, rice (Giza101), rice (Giza 177), broad bean, corn (hyb. 310), corn (hyb. 352), wheat (Giza9) and wheat (Giza 168) respectively. The previous result**s** showed a variation in terminal velocity for the varieties of the same crop due to the variation in particle mass, air and particle density. Hence, the difference in terminal velocity offers the possibility of separating such materials from each other in an air stream and it can be utilized in designing air screen, threshing, cleaning and grading equipment

-Reynold's number:

Projected area , drag coefficient and Reynold's number were determined. The obtained results indicated that Reynold's number of the terminal velocity of the studied grains exceeds the critical velocity of (2100) **EL–Raie *et al*. (1996),** in the range of turbulent flow except the fennel flower seeds. So, it is necessary to determine the Reynold's number for the different varieties of each crop.

Table (4): Some physical and aerodynamic properties of fennel flower seed.

symbol	L	W	T	V	D_g	D_a	A_p
Max.	3.160	1.410	1.900	3.704	1.920	2.043	3.398
Min.	2.390	1.010	0.600	1.117	1.287	1.523	2.045
Sum.	309.95	134.510	96.730	184.31	158.54	180.397	305.996
Mean	2.897	1.257	0.904	1.723	1.482	1.686	2.860
St.Dev.	0.132	0.070	0.165	0.341	0.093	0.074	0.220
C.V.	4.572	5.581	18.298	19.781	6.268	4.401	7.698
symbol	M	S%	A_f	A_t	v_t	C_d	N_{Re}
Max.	0.004	64.428	3.400	1.865	4.500	1.147	570.342
Min.	0.002	42.122	2.046	0.564	3.500	0.632	378.620
Sum.	0.283	5481.406	306.151	95.497	446.90	86.658	53683.883
Mean	0.003	51.228	2.861	0.892	4.177	0.810	501.719
Std.Dev	0.000	3.549	0.220	0.170	0.249	0.099	33.514
C.V.	17.901	6.927	7.698	19.070	5.962	12.258	6.680

Table (5): Some physical and aerodynamic properties of rice (Giza101).

symbol	L	W	T	V	D_g	D_a	A_p
Max.	8.980	4.900	4.130	58.605	4.820	5.163	29.011
Min.	5.290	3.010	2.010	23.423	3.550	3.887	14.555
Sum.	1099.50	527.850	369.950	4992.725	596.384	665.767	3036.930
Mean	7.330	3.519	2.466	33.285	3.976	4.438	20.246
Std.Dev	0.539	0.389	0.359	6.607	0.250	0.246	2.661
C.V.	7.357	11.053	14.544	19.850	6.276	5.537	13.144
symbol	M	S%	A_f	A_t	v_t	C_d	N_{Re}
Max.	0.035	72.469	29.026	12.098	9.000	0.662	3305.800
Min.	0.003	45.326	14.563	5.099	5.700	0.062	1654.915
Sum.	4.019	8169.295	3038.47	1023.5	1099.200	58.466	351118.8
Mean	0.027	54.462	20.256	6.823	7.328	0.390	2340.792
Std.Dev	0.003	4.507	2.662	1.315	0.848	0.080	316.078
C.V.	12.815	8.276	13.144	19.278	11.578	20.633	13.503

Table (6):Some physical and aerodynamic properties of rice (Giza177).

symbol	L	W	T	V	D_g	D_a	A_p
Max.	8.590	5.390	3.960	64.763	4.983	5.257	32.072
Min.	6.280	3.010	2.020	24.440	3.601	3.980	15.734
Sum.	1099.150	571.570	385.450	5644.114	620.269	685.390	3287.666
Mean	7.328	3.810	2.570	37.627	4.135	4.569	21.918
Std.Dev	0.364	0.522	0.426	8.785	0.308	0.263	3.183
C.V.	4.963	13.695	16.561	23.348	7.455	5.755	14.525
symbol	M	S%	A_f	A_t	v_t	C_d	N_{Re}
Max.	0.037	72.142	32.088	13.032	8.900	0.654	3198.765
Min.	0.002	49.283	15.742	5.252	4.300	0.081	1327.054
Sum.	3.832	8480.139	3289.33	1156.20	1053.600	56.177	349766.22
Mean	0.026	56.534	21.929	7.708	7.024	0.375	2331.775
Std.Dev	0.004	4.630	3.185	1.762	0.916	0.089	341.967
C.V.	15.686	8.189	14.525	22.863	13.037	23.692	14.666

Table (7) :Some physical and aerodynamic properties of broad bean.

symbol	L	W	T	V	D_g	D_a	A_p
Max.	18.410	15.980	10.170	1397.336	13.873	14.337	214.315
Min.	13.330	13.010	7.010	720.118	11.123	11.547	136.974
Sum.	2437	2062.880	1280.380	149673.55	1856.453	1926.897	26313.987
Mean	16.250	13.753	8.536	997.824	12.376	12.846	175.427
Std.Dev	1.072	0.549	0.935	131.666	0.544	0.494	13.546
C.V.	6.597	3.992	10.950	13.195	4.397	3.844	7.722
symbol	M	S%	A_f	A_t	v_t	C_d	N_{Re}
Max.	1.280	88.762	214.424	114.219	26.550	0.325	25467.554
Min.	0.540	66.723	137.044	72.730	12.850	0.134	11352.167
Sum.	129.37	11460.38	26327.33	13828.88	3023.940	28.574	2845225.457
Mean	0.862	76.403	175.516	92.193	20.160	0.190	18968.170
Std.Dev	0.145	4.706	13.553	10.632	3.098	0.033	2983.259
C.V.	16.787	6.160	7.722	11.532	15.370	17.135	15.728

Table (8): Some physical and aerodynamic properties of corn (hyb.310).

symbol	L	W	T	V	D_g	D_a	A_p
Max.	15.390	11.570	8.180	442.452	9.456	10.383	130.043
Min.	8.690	6.010	3.010	101.683	5.792	6.357	49.361
Sum.	1761.880	1369.850	655.930	**36801.555**	1156.786	1262.553	12712.877
Mean	11.746	9.132	4.373	245.344	7.712	8.417	84.753
Std.Dev	1.494	1.108	0.848	61.773	0.668	0.738	17.619
C.V.	12.718	12.132	19.389	25.178	8.658	8.772	20.789
Symbol	M	S%	A_f	A_t	v_t	C_d	N_{Re}
Max.	0.590	88.372	130.109	48.355	16.970	0.573	13687.853
Min.	0.210	51.756	49.386	17.012	14.210	0.180	7261.607
Sum.	63.430	9946.311	12719.325	4694.66	2301.650	50.323	1499548.836
Mean	0.423	66.309	84.796	31.298	15.344	0.335	9996.992
Std. Dev	0.079	7.138	17.628	6.689	0.710	0.078	1206.270
C.V.	18.639	10.764	20.789	21.373	4.630	23.167	12.066

Table (9): Some physical and aerodynamic properties of corn (hyb.352)

symbol	L	W	T	V	D_g	D_a	A_p
Max.	14.985	10.949	6.880	434.704	9.400	9.908	109.640
Min.	10.085	5.486	3.020	106.170	5.876	6.570	44.519
Sum.	1845.063	1237.071	680.470	36225.485	1149.467	1254.201	11959.439
Mean	12.300	8.247	4.536	241.503	7.663	8.361	79.730
Std.Dev.	1.047	1.246	0.904	66.478	0.708	0.657	14.227
C.V.	8.514	15.103	19.929	27.527	9.241	7.861	17.844
symbol	M	S%	A_f	A_t	v_t	C_d	N_{Re}
Max.	0.540	79.560	109.696	50.910	16.300	0.623	11340.741
Min.	0.180	46.207	44.542	14.031	13.500	0.139	6783.022
Sum.	45.390	9379.371	11965.505	4406.109	2203.460	42.408	1393455.01
Mean	0.303	62.529	79.770	29.374	14.690	0.283	9289.700
Std.Dev.	0.056	5.838	14.234	7.326	0.725	0.088	968.678
C.V.	18.471	9.337	17.844	24.941	4.933	31.118	10.427

Table (10): Some physical and aerodynamic properties of Wheat (Giza 9).

symbol	L	W	T	V	D_g	D_a	A_p
Max.	7.580	5.970	3.910	74.698	5.226	5.433	30.365
Min.	5.290	3.010	2.060	19.495	3.340	3.557	12.939
Sum.	953.610	591.270	481.530	6400.404	644.988	675.470	2957.029
Mean	6.357	3.942	3.210	42.669	4.300	4.503	19.714
Std .Dev	0.410	0.630	0.449	11.606	0.399	0.363	3.600
C.V.	6.455	15.977	14.000	27.201	9.276	8.055	18.264
symbol	M	S%	A_f	A_t	v_t	C_d	N_{Re}
Max.	0.066	83.829	30.381	17.114	10.500	0.976	3649.353
Min.	0.022	53.204	12.946	5.169	5.100	0.335	1330.663
Sum.	7.048	10162.033	2958.529	1505.871	1201.200	88.459	377978.874
Mean	0.047	67.747	19.724	10.039	8.008	0.590	2519.859
Std.Dev	0.009	5.903	3.602	2.539	1.078	0.123	418.422
C.V.	19.484	8.713	18.264	25.287	13.468	20.844	16.605

Table (11): Some physical and aerodynamic properties of Wheat (Giza 168)

symbol	L	W	T	V	D_g	D_a	A_p
Max.	7.550	5.120	4.250	63.999	4.964	4.997	24.862
Min.	5.060	3.010	2.010	20.942	3.420	3.683	12.416
Sum.	938.710	543.870	480.500	5721.544	622.842	654.360	2671.372
Mean	6.258	3.626	3.203	38.144	4.152	4.362	17.809
Std. Dev	0.453	0.432	0.533	8.661	0.325	0.281	2.443
C.V.	7.232	11.917	16.652	22.706	7.823	6.446	13.719
symbol	M	S%	A_f	A_t	v_t	C_d	N_{Re}
Max.	0.066	88.321	24.875	17.090	9.900	1.098	3092.319
Min.	0.020	49.321	12.422	5.020	4.700	0.432	1385.294
Sum.	6.324	9993.87	2672.727	1374.434	1137.30	99.028	339898.182
Mean	0.042	66.626	17.818	9.163	7.582	0.660	2265.988
Std. Dev	0.007	6.415	2.445	2.054	1.209	0.150	365.617
C.V.	17.286	9.629	13.719	22.420	15.948	22.783	16.135

CONCLUSION

Some physical and engineering properties of some field crops are presented in this study and it can be concluded that:

1. Stainless steel or galvanized iron have the lowest values of coefficient of friction so, It is recommended to use the stainless steel or galvanized iron in manufacturing of seed hopper used in planting machines, silos and storage containers with sides inclination of 40° to allow an easily sliding for the studied grains.

2. The bulk density, geometric diameter, arithmetic diameter, sphericity and the seed three axial dimensions, length (L), width (W) and thickness (T) were determined. The physical properties of seed play an important

role to select the proper sorting, separating and cleaning equipment and the main dimensions are considered in selecting and designing the suitable size of the screen perforations.

3. Seed projected area, coefficient of drag and terminal velocity were estimated. The average terminal velocities of grains were 4.17, 7.32, 7.02, 20.16, 15.34, 14.69, 8.00 and 7.58 m/s for fennel flower, rice (Giza101), rice (Giza 177), broad bean, corn (hyb. 310), corn (hyb. 352), wheat (Giza9) and wheat (Giza 168) respectively.

4. The results showed that Reynold's number of the terminals velocity of the studied grains exceeds the critical velocity of Reynold's number (R_N=2100) in the range of turbulent flow except the fennel flower seeds.

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الملخص العربي

دراسة الخصائص الفيزيائية والهندسية لحبوب بعض المحاصيل الحقلية

يحيى عبد الحميد الفوال * محمد على توفيق أحمد محمد سعد الدين الشال****

تهدف هذه الدراسة إلى توفير قاعدة بيانات ومعلومات عن الخصائص الطبيعية والهندسية لبذور بعض محاصيل الحبوب الصناعية والغذائية وهذا لأهميتها القصوى في تشغيل وتصميم بعض أجزاء من الألات المستخدمة في عمليات الزراعة ، الحصاد ،التدريج، التداول، ، التنظيف و تمت الدراسة على عدة بذور لأصناف مختلفة من محاصيل حبة البركة، الأرز (جيزة١٠١)، الأرز (جيزة ١٧٧)، فول بلدي، ذرة (هجين ثلاثي٣١٠)، ذرة (هجين ثلاثي٣٥٢)، قمح (جيزة ٩) وقمح (جيزة ١٦٨) وتم أختيار المحاصيل من حيث الأهمية الغذائية والمساحة المنزرعة والتوسع المستقبلي في زراعتها .الخواص التي تم قياسها هي الخصائص الطبيعية وتشمل كل من الطول ـ العرض ـ السمك ـ الحجم ـ وزن الحبة ـ وزن الألف حبة ـ نسبة الكروية ـ القطر الهندسي ـ القطر الرياضي ـ مساحة السطح ـ الكثافة الظاهرية بينما الخصائص الهندسية تشمل كل من الخصائص الميكانيكية (معامل الأحتكاك ـ زاوية التكويم) و الخصائص الأيروديناميكية (سرعة التعليق ـ معامل الانجراف ـ رقم رينولدز) عند محتوي رطوبي للتخزين يتراوح من ٧ الي ١٢% (أساس رطب) ويمكن تلخيص النتائج كالأتي :

- توصي الدراسة بتصنيع جدران صناديق البذور والسايلوهات و الصوامع من مادة الأستنليس ستيل ويليه الحديد المجلفن بسسبب أنخفاض معامل أحتكاكهما بزاوية قدرها ٤٠ درجة لتسمح بانزلاق البذورتحت الدراسة بسهولة.

- حساب الخصائص الطبيعية تساعد علي أختيار الغرابيل وأقطار ثقوبها وكذلك أختيار ألات التدريج والفصل المناسبة لبذور كل محصول.

- متوسط سرعة التعليق كانت ٤.١٧، ٧.٣٢، ٧.٠٢، ٢٠.١٦، ١٥.٣٤، ١٤.٦٩، ٨.٠٠ و٧.٥٨ م\ث لحبة البركة، الأرز (جيزة١٠١)، الأرز (جيزة ١٧٧)، فول بلدي، ذرة (هجين ثلاثي٣١٠)، ذرة (هجين ثلاثي٣٥٢)، قمح (جيزة ٩) وقمح (جيزة ١٦٨) علي الترتيب حيث تساعدهذه النتائج في عمليات التنظيف و الفصل والدراس.

- اظهرت النتائج أن قيم رقم رينولدالخاصة بسرعة التعليق لجميع حبوب المحاصيل تحت الدراسة -ماعدا حبة البركة- تقع في نطاق السريان المضطرب والتي تتعدي فيها قيمة السرعة الحرجة وفقاّ لرقم رينولد(٢١٠٠).

* باحث – معهد بحوث الهندسة الزراعية – الجيزة- مصر،

** مدرس الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق- مصر.