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THE RESULT OF THE EXPERIMENT DETERMINING THE BREAKING FORCE OF GRAIN HULL GROWN IN THE CONDITIONS OF MONGOLIA DEPENDING ON ITS MOISTURE

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Huller Machine, Statistical Analysis, Breaking Force, Moisture.

ABSTRACT

The objectives of the long-term development policy of Mongolia "VISION-2050" include scientific and knowledge-based development of agricultural production with the sight of sustainable development, the ability to transform knowledge into practice, the introduction of advanced technologies and innovations, the extension of agricultural raw materials and products in a foreign market, suspending the import of certain types of raw materials and products, and increasing exports.
To implements the policy, it is necessary to carry out a scientific study on the process of hulling technology for all types of grain production and to select the key parameters of design and technology of the huller machine, the breaking force of grain hull depending on its moisture was determined by experimenting 100-grain seeds with the experiment being repeated 3-5 times in laboratory environment. The result of the study is presented by using mathematical statistical analysis methods on the numerical data.

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BASIS OF RESEARCH WORK.

As the development of the countries of the world accelerates, the issue of food supply and food security of the population has become more urgent. National programs are being implemented throughout Mongolia to develop agricultural production and sales network, to fully meet the needs of staple food products domestically, and to support the production of import-substituting and export-oriented products.

In recent years, the annual increase in grain yield and import indicates the interest and need of small machinery for hulling grain suitable for the conditions of our country for individuals and enterprises engaged in production in this field.

The purpose of this research work is to test the breaking force of the grain hull depending on its moisture in laboratory conditions and to determine the results by applying mathematical statistical analysis methods to the numerical data extracted.

RESEARCH MATERIALS AND METHODS.

The experiment will be carried out according to the method of determining the breaking force of the grain hull [4,5,6].

The relationship between grain moisture and the breaking force of grain hull is considered a linear and curvilinear relationship.

The mathematical statistical processing is performed on the sample data and quantitative indicators are determined [1].

Grain materials and equipment used for the experiment:

Wheat sort: Darkhan 181, Altai Krai 325;

Buckwheat sort: Zemlyachkii;

Barley sort: Nerdit, Copiland;

Oat sort: Granii;

A device for determining elastic deformation coefficient of the grain (Figure 1). Certificate of useful design № 20-0003333);

Grain moisture measurer (WILE55. Finland);

Digital microscope (DM-1000S. China);

Electron balance. (JJ-200. [0.01gr]. China).

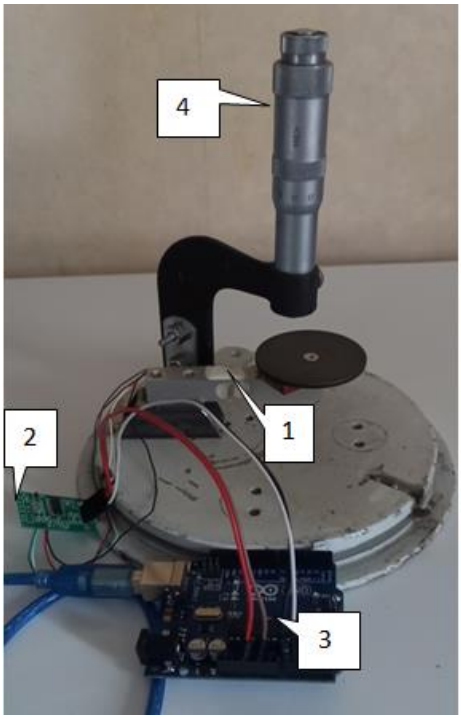

Figure 1. A machine to test breaking force of grain hull depending on its moisture: 1-Load cell, 2-HX711 ATX, 3- Arduino Uno, 4- Micrometer.

RESULT OF THE RESEARCH.

Using the laboratory equipment for determining the breaking force of the grain hull, experiments were conducted on each crop with 10 different moisture levels (11.6-17.8%) and the experiment was repeated 5-10 times per moisture level for a total of 100 seeds. The following table

shows the results of experimental measurements of the experiment determining the breaking force of the grain hull depending on its moisture (Table 1).

Here, it can be seen that the numerical data of the breaking force of grain hull experiment for each grain corp obey the normal distribution law with the Kolmogorov-Smirnov Dn-criterion.

Including:

Moisture: K-Sd=D_n=max|$F_n(x)$-F(x)|=0.2235<$D_{7,0,05}$=0.4834.

Buckwheat: K-Sd=D_n=max|$F_n(x)$-F(x)|=0.1775<$D_{7,0,05}$=0.4834.

Wheat: K-Sd=D_n=max|$F_n(x)$-F(x)|=0.2295<$D_{7,0,05}$=0.4834.

Barley: K-Sd=D_n=max|$F_n(x)$-F(x)|=0.1907<$D_{7,0,05}$=0.4834.

Oat: K-Sd=D_n=max|$F_n(x)$-F(x)|=0.1488<$D_{7,0,05}$=0.4834.

According to the results of the regression analysis of the relationship between the breaking force of grain hull and moisture, the coefficients of determination are R^2=0.98-0.99, which indicates that the breaking force of grain hull strongly depends on moisture with 98-99%. (Tables 2-5).

From the result of dispersion analysis, according to Fisher's exact test $F_{experiment}$=(124.16-333.74)>F_{theory}(2,4,0.05)=19.25, the curvilinear form of the regression curve is plausible and consistent with a probability of 0.95%.

From the figure, the force to break the grain hull depending on its moisture can be illustrated (Figure 6).

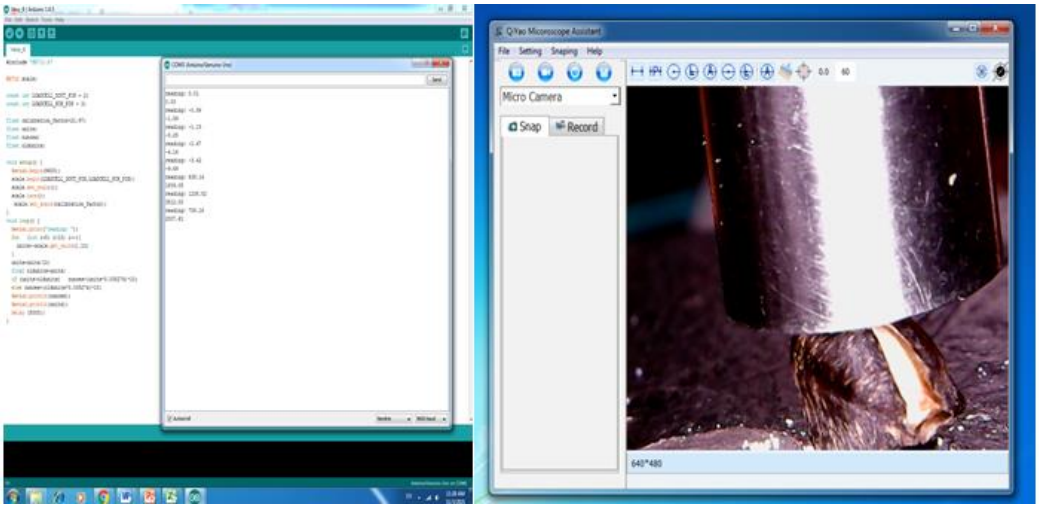

Figure 2. Experiment picture: Picture of grain hull breaking and data received from the measuring device.

Table 1. Numerical data is generated from the result of experiments and measurements. Numerical data is generated by average values.

Moisture, %	Wheat, H	Barley, H	Buckwheat, H	Oat, H
11.6	9.5	102	31	58
13.1	8.1	93	29	51.3
14.3	6.8	87	26.5	49.5
15	6.2	82.3	24.2	45.6
16.5	5.8	75.1	23	43.2
17	5.6	72	22	41
17.8	5.5	71.6	20.8	39.5

Table 2. Results of analysis of curvilinear regression equation between breaking force and moisture content of wheat.

N=7	Regression Summary for Dependent Variable: Wheat, F4, H (Spreadsheet 1) R= .99638154 R^2= .99277618 Adjusted R^2= .998916427 F(2,4)=274.86 p<.00005 Std.Error of estimate: .15596					
	b*	Std.Err. of b*	b	Std. Err. of b	t(4)	p-value
Intercept			38.20297	3.425584	11.15225	0.000368
Moisture, W,%	-5.41977	0.699461	-3.64747	0.470733	-7.74850	0.001495
W^2	4.46936	0.699461	0.10172	0.015920	6.38972	0.003079

Table 3. Results of analysis of curvilinear regression equation between breaking force and moisture content of barley.

N=7	Regression Summary for Dependent Variable: Barley, F1, H (Spreadsheet 18) R= .99701709 R^2= .99404308 Adjusted R^2= .99106462 F(2,4)=333.74 p<.00004 Std.Error of estimate: 1.0849					
	b*	Std.Err. of b*	b	Std. Err. of b	t(4)	p-value
Intercept			213.7790	23.82835	8.97163	0.000854
Moisture, W,%	-2.42751	0.635171	-12.5142	3.27442	-3.82182	0.018749
W^2	1.43698	0.635171	0.2505	0.11074	2.26235	0.086456

Table 4. Results of analysis of curvilinear regression equation between breaking force and moisture content of buckwheat.

N=7	Regression Summary for Dependent Variable: Buckwheat, F3, H (Spreadsheet 1) R= .99204211 R^2= .98414754 Adjusted R^2= .97622131 F(2,4)=124.16 p<.00025 Std.Error of estimate: .58111					
	b*	Std.Err. of b*	b	Std.Err. of b	t(4)	p-value
Intercept			60.42981	12.76381	4.73447	0.009074
Moisture, W,%	-1.80655	1.036164	-3.05803	1.75396	-1.74350	0.156198
W^2	0.81726	1.036164	0.04679	0.05932	0.78874	0.474384

Table 5. Results of analysis of curvilinear regression equation between breaking force and moisture content of oat.

N=7	Regression Summary for Dependent Variable: Oat, F2, H (Spreadsheet 1) R= .99319120 R^2= .98642875 Adjusted R^2= .97964313 F(2,4)=145.37 p<.00018 Std.The error of estimate: .92882					
	b*	Std.Err. of b*	b	Std. Err. of b	t(4)	p-value
Intercept			122.8162	20.40100	6.02011	0.003835
Moisture, W,%	-2.52330	0.958716	-7.3785	2.80344	-2.63196	0.058067
W^2	1.53735	0.958716	0.1520	0.09481	1.60355	0.184077

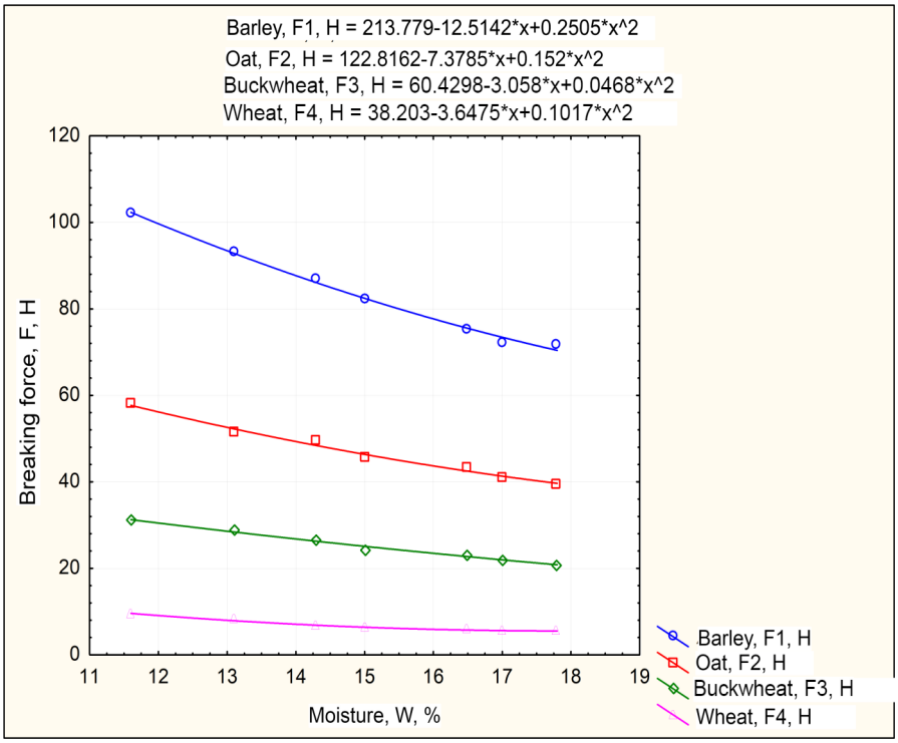

Figure 6. The graph of the relationship between grain moisture and the breaking force of its hull.

DISCUSSION.

If we study the technology of compressing and rubbing of the huller machine used in production, it can be noticed that the cost of operation is high due to the deformation of compressing and rubbing which causes the wear of the components to be high, the availability of the components is low, the energy consumption is high, and the settings must always be checked and adjusted during operation. If the settings are not adjusted, it will result in a lot of waste products, as well as the worn material from components can be mixed into the product. It is a complicated procedure to replace the component which no longer can be adjusted, and requires professional skills from the technical staff who is operating the machine. The above-mentioned are the disadvantages of the machine.

By selecting the physical and mechanical properties of the material which is used for compressing and rubbing, it has advantages such as high hulling yield rate, minimal wear of

components, low energy consumption, minimal adjustment needed, and professional skills are not required from the staff, and clean products extracted in terms of hygiene.

CONCLUSION.

1. The mathematical model of the breaking force of the grain hull depending on its moisture is parabolic.
   - Breaking force of wheat =38.203−3.6475∗W+0.1017∗W^2;
   - Breaking force of barley =213.779−12.5142∗W+0.2505∗W^2;
   - Breaking force of buckwheat =60.4298−3.058∗W+0.0468∗W^2;
   - Breaking force of oat =122.8162−7.3785∗W+0.152∗W^2.
2. As the moisture content of the grain increases, the breaking force of the grain hull decreases.
3. It will be possible to determine the breaking force of the grain hull containing different moisture content using a mathematical model.
4. From the result of dispersion analysis, according to Fisher's exact test $F_{experiment}$=(124.16-333.74)>F_{theory}(2,4,0.05)=19.25, the curvilinear form of the regression curve is plausible and consistent with a probability of 0.95%.
5. When the moisture content of the grain is about 11.6-17.8%, the breaking force of wheat hull is 9.5-5.5 N, the breaking force of barley hull 102-71.6 N, the breaking force of buckwheat hull is 31-20.8 N, and the breaking force of oat hull is 58-39.5 N.
6. If the hulling process is carried out when the breaking force of the hull of each grain is lower than the above-mentioned force with a moisture content of grain is in the range of (11.6-17.8)%, the condition will be that the grain will not break.

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