

# Influence of Physical and Mechanical Properties and Condition of Barley Grain on Damage During Mechanical Processing

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**Abstract** –To assess the extent of injury of barley seeds by the working parts of agricultural machinery, it is suggested to check their germination using an aeroponics device along with ways of visual control of the amount of mechanical damage. On the basis of the carried out experimental researches impact of traumatization on germination of seeds of barley depending on its physical and mechanical properties and a condition of grain material is established. The experimental dependences are given, according to which the extremum is observed - the maximum value of germination in the permissible range of variation of moisture content for different values of the number of grain passes through the machine.

**Keywords**—grain, barley, damaging ability of machines, technological line, mechanical damage, laboratory germination of seeds, number of grain passes through the machine.

## I. INTRODUCTION

The basis for the stability of high yields of agricultural crops is high-quality seeds. But in the process of harvesting, post-harvest and pre-sowing treatment there is the occurrence of mechanical damage to the seed material. The degree of damage to the grain depends on the type of grain, its condition, physical and mechanical properties, as well as the type of technological operation performed. This is due to the fact that when interacting with the working bodies of machines in individual grains there are stresses exceeding the strength limit and, as a consequence, initially there is microtrauma, that is, the fruit shells, endosperm and embryo are damaged, then there is macrotrauma, that is, grinding or crushing of grain [1]. Crushed grains on machines for post-harvest processing fall into waste and do not affect the quality of the grain batch in the future. Grains with microtrauma remain in the batch and affect the stability of the seed batch during storage, subsequent processing and processing, as well as reduce the germination of grain material.

The total index of mechanical damage  $\delta_T$  according to [2], [3], [4] it is defined as the sum of  $i$ -types of injuries on the basis of visual inspection of specially prepared samples. In particular, for such an important agricultural crop as barley, the total index of mechanical damage is the sum of the number of grains with a cracked shell, partially collapsed and completely lost the fruit shell (microtraumatized grains) and the number of crushed grains (macrotraumatized grains).

However, based on many years of experience in the study of grain batches for mechanical damage, it turns out that visual inspection does not always give an objective assessment of the quality of seed material. Namely, there is not always an unambiguous correspondence between the growth, development of a batch of seeds with micro-damage and the influence of external conditions of plant growth. It would seem that the grain, visually classified as micro-damaged, once in adverse conditions, should not rise at all, in fact, it rises and develops further. The reason for this seems to be the inadequacy of the significance of visible damage to seeds with further consequences of plant development. Because of this, along with visual inspection, other methods of grain structure analysis are required, requiring special diagnostic equipment. One such method is to test seed samples for laboratory germination according to a standard procedure. At the same time, having conducted a large number of experiments to determine the laboratory germination of grain samples with visually detected micro-damage, it was found that there is no complete guarantee that the grain with visually marked damage will not grow, and even there is a slight increase in the degree of germination of such seeds. Thus, one of the objectives of this study is to establish the conformity of the evaluation results with direct (organoleptic) and indirect (biological) methods [2].

To improve the accuracy of such an assessment of the effect of microtrauma on seed germination, the authors [5], [6], [7], [8], [9] variants of tightening of conditions of testing of seeds on germination, i.e. creation of conditions close to field were offered. In one of these variants, it was proposed to test the seeds for laboratory germination in accordance with the standard procedure, but with one difference – the bed in which the seeds are placed is pre-moistened with 0.05-0.07% sulfuric acid solution. In another embodiment, the seeds with microdamage and control seeds pre-soaked in 50% strength sulfuric acid for a certain time, in particular for barley seed, such exposure was 15 minutes, after that seeds were washed with distilled water and planted in soil to a depth of 5-6 cm after a certain time (5-15 days) the quality of the results was assessed by comparison of seedlings derived from the samples microtraumatized seed, with seedlings from seeds of control sample.

The above methods give a positive result-improving the quality of accuracy assessment by direct and indirect

methods. But, in our opinion, along with the methods of tightening have the right to life and favored methods, for example, seed germination is not in a laboratory thermostat, and in a special aeroponic installation, where in addition to adjusting the temperature, the speed and humidity of the air flow is adjusted.

The purpose of research: to increase the efficiency of mechanized processing of barley seeds based on reducing mechanical damage.

Tasks:

1. Determination of the influence of moisture batches of barley seeds, after mechanized processing on their germination.
2. Determination of germination of barley seeds depending on the number of grain passes through the machine.
3. Establishing a correspondence between the results of visual determination of the amount of mechanical damage in batches of grain that have undergone mechanized processing with the result of control of the same batches for germination.

**II. MATERIALS AND METHODOLOGY**

Determination of germination of grain material that has undergone mechanized processing was carried out in the laboratory using the aeroponic device «Rosinca» [10].

For the experiment, samples of barley seeds of different humidity were artificially processed on a «shock machine» [11], [12] Then each sample in accordance with the procedure [11] was divided into three parts: whole, micro-damaged and crushed grains. After that whole and micro-damaged grains from each sample were subjected to germination testing in the above-mentioned installation. The bookmark was carried out in special trays-containers (Fig.1 – Fig.5). The modes of work were the following: the supply of wet saturated air was 30 ml/h, ambient temperature in the germinator – 23<sup>0</sup>C. The experiments were carried out in threefold repetition.

**III. EXPERIMENTAL RESULT**

After three days from the moment of laying, the seeds were counted with strong sprouts, weak sprouts and seeds without sprouts (table 1).

TABLE I. GERMINATION OF BARLEY SEEDS OF DIFFERENT HUMIDITY WITH DIFFERENT NUMBER OF PASSES THROUGH THE MACHINE

Number of passes	Humidity, %					
	10	15	20	25	30	35
0	87.82	87.82	87.82	87.82	87.82	87.82
5	78.05	70.96	31.74	12.45	0.00	0.00
10	52.76	65.44	20.51	4.75	0.00	0.00
15	19.68	37.25	7.16	0.57	0.00	0.00
20	17.14	26.25	3.70	0.23	0.00	0.00
25	4.26	10.26	0.33	0.00	0.00	0.00

According to the results of germination in Fig. 1 – Fig. 5 visually, it is noted that with an increase in the number of grain passes through the machine, the number of sprouted seeds decreases, and with the number of passes 15, 20, 25 the sprouts are almost invisible. In addition, it can be seen that the repeatedly injured grains are covered with mold, that is, their further germination is impossible.

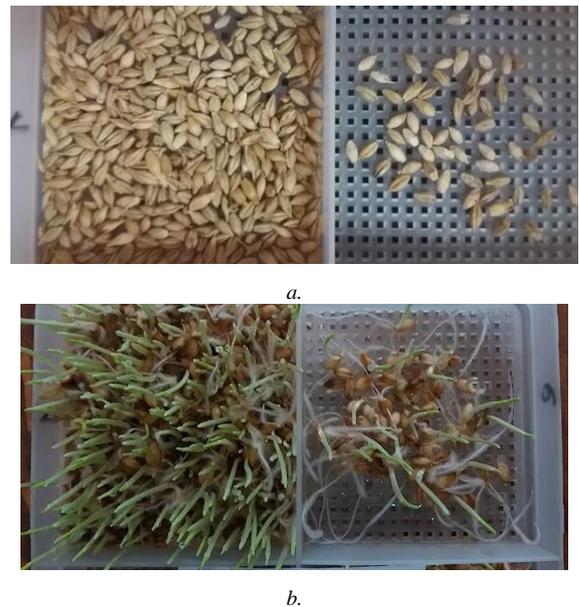


Fig. 1. 10% moistured grain before (a) and after (b) germination with five passes through the machine.

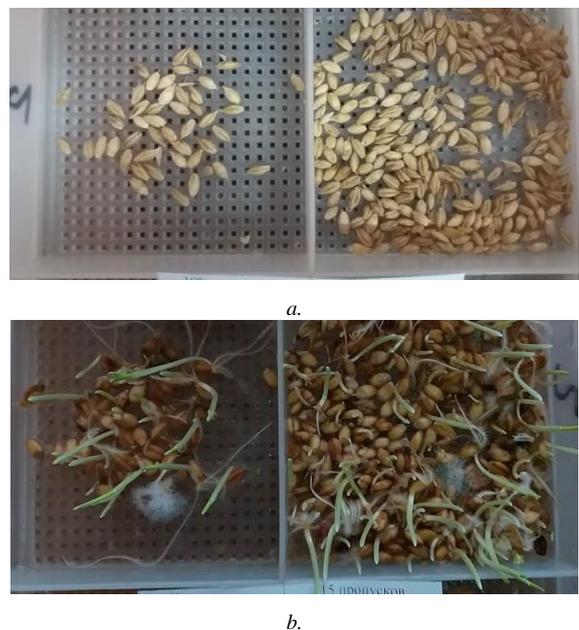
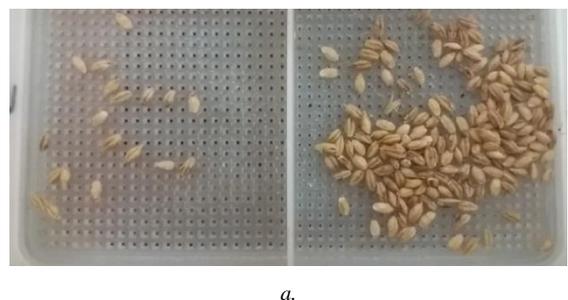


Fig. 2. 10% moistured grain before (a) and after (b) germination with ten passes through the machine.





b.

Fig. 3. 10% moistured grain before (a) and after (b) germination with fifteen passes through the machine.

There are whole grains on the left, grain without fruit shells on the right in Fig.1 – Fig.3.



a.

b.

Fig. 4. 10% moistured grain before (a) and after (b) germination with twenty passes through the machine (only grain without fruit shells).



a.

b.

Fig. 5. 10% moistured grain before (a) and after (b) germination with twenty five passes through the machine (whole grains on the left, grain without fruit shells on the right).

According to table.1 in Fig. 6 and Fig. 7 graphic dependences of grain germination on the number of passes at different moisture are plotted.

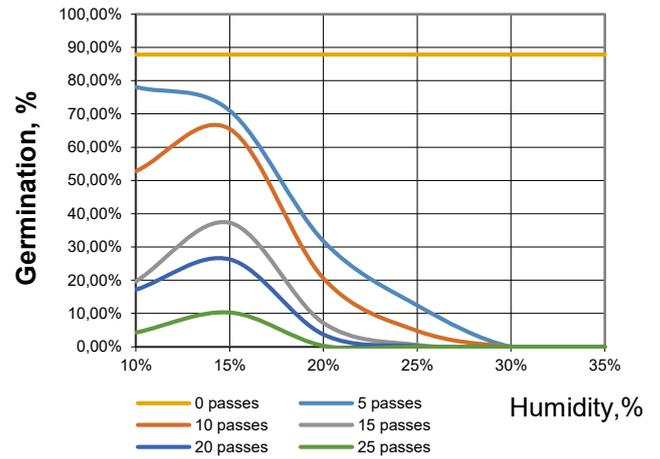


Fig. 6. Dependence of barley seed germination on humidity at different numbers of passes.

The value of the total index of mechanical damage  $\delta_{II} = \delta_{II}(v, W, \beta)$  depending on the number of passes of barley grain through the machine and its humidity, the results of visual inspection can be determined by the expression [9]

$$\delta_{II}(v, W, \beta) = 1 - ((1.3499 + 0.1065W - 0.0022W^2)\beta)^v \quad (1)$$

where  $v$  – the number of grain passes through the machine;

$W$  – grain moisture, %;

$\beta$  – damaging ability of the machine (in our case for «shock machine»  $\beta=1$ )

The dependence is built in Fig. 7 with the number of passes 5, 10, 15, 20, 25.

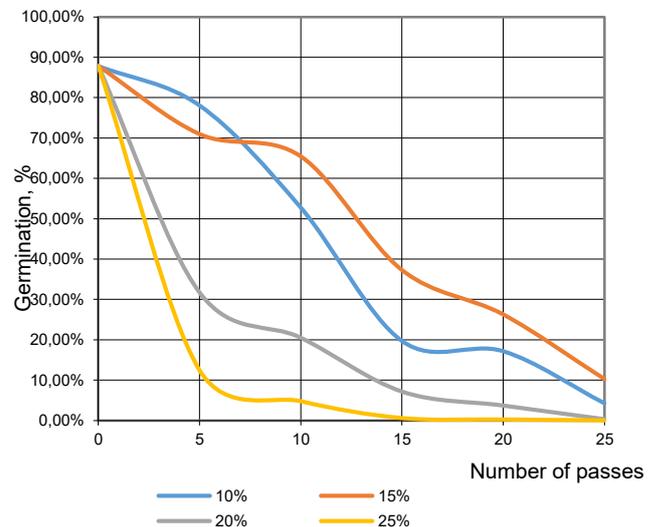


Fig. 7. Dependence of barley seed germination on the number of passes at different humidity.

The humidity at which the grain receives the least amount of mechanical damage can be determined by studying the function (1) at the extremum. To do this,  $v=1$  find the derivative and equate it to zero

$$\frac{\partial \delta_{II}(\nu, W, \beta)}{\partial W} = \nu \cdot (1.3499 + 0.1065W - 0.0022W^2)^{\nu-1}$$

$$0.0044W - 0.1065 = 0$$

Where  $W=24.2\%$ . When moisture changes  $\pm 2\%$  of the obtained minimum values determine the range of variation  $\delta_{II}$  at different  $\nu$ . Deviation  $\delta_{II}$  from minimum values at different numbers of passes  $\nu$  be about 10-15%, because of the high variability of the parameters of the grain mixture may be within the error of the experience. Therefore, from 22 to 26% - it can be considered a range of humidity in which the grain receives a minimum of damages.

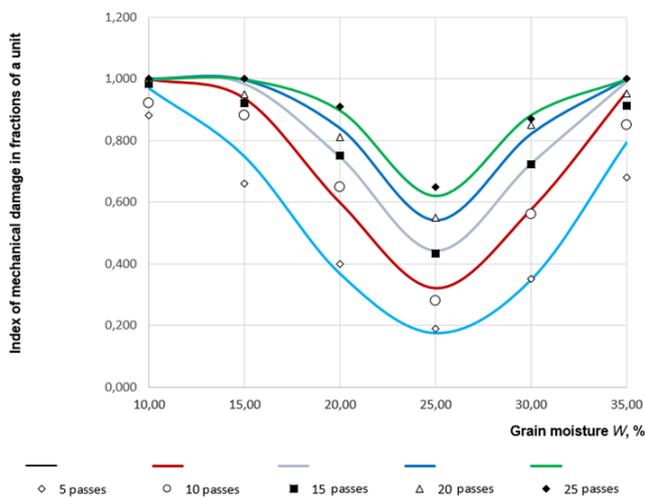


Fig. 8. Dependence of mechanical damages index of barley seeds on humidity at different number of passes.

Comparing the obtained graphic dependences in Fig. 6 and Fig. 8, it should be noted that the minimum damage according to the results of visual inspection (Fig. 8) observed at a humidity of about 24%, and a maximum germination (Fig. 6) - at a humidity of about 15%.

#### IV. DISCUSSION OF RESULTS

Taking into account the given graphic dependences and data of visual control of germination, it can be noted that

1. With an increase in the number of passes seed through the machine at the same humidity the speed of their germination decreases.
2. The minimum damage according to the results of visual inspection is observed at grain moisture of 24.2%.
3. The maximum germination of seeds is observed at grain moisture of 15%.
4. Barley grains that have lost the shell have lower germination than grains that are not damaged by an average of 20%.
5. Damaged sprouted grains are characterized by weak sprouts.

The discrepancy between the extreme values of the index of mechanical damage during visual inspection and determination of germination depending on humidity when testing the same samples is explained by the fact that samples of whole (intact) grains at a humidity of more than 15% include grains with visually invisible damage. In this regard, the visual inspection of grain samples for mechanical damage

with a moisture content of more than 15% is inaccurate and requires correction, for example, according to the method proposed by us.

It should also be noted that the process of obtaining grain damage at different humidity is elastic-plastic in nature, namely, at humidity less than 15% deformation elastic, from 15 to 25% deformation combined (elastic-plastic), and at humidity more than 25% deformation purely plastic. And since the experiment shows that at a humidity of more than 20% there is a significant decrease in germination, the plastic deformation of seeds are the most dangerous and mechanized processing of seed batches of barley of such humidity can cause serious damage to grain production.

#### V. CONCLUSION

To reduce mechanical damage to barley seeds and improve production efficiency should:

1. Harvesting, post-harvest and pre-sowing treatment of barley should be carried out at a grain moisture content not higher than 20%;
2. To organize the technological process so that the number of grain passes through the machines of technological lines was minimal;
3. To carry out quality control of batches of seeds for mechanical damages, combining visual control of samples with checking them for germination according to the proposed method.

#### REFERENCES

- [1] A. P. Tarasenko, Snizhenie travmirovaniya semyan pri uborke i posleuborochnoj obrabotke [Reduction of injury of seeds during harvesting and post-harvest processing]. Voronezh: Voronezh state agrarian university Publ., 2003. (in russ.)
- [2] A. N. Pugachev, Povrezhdenie zerna mashinami. [Grain damage by machines]. Moscow: Kolos Publ., 1976. (in russ.)
- [3] H. F. Ng, W. F. Wilcke, R. V. Morey, R. A. Meronuck and J. P. Lang, Mechanical damage and corn storability. Transactions of the American Society of Agricultural Engineers, Vol. 41, pp. 1095-1100, 1998. <https://doi.org/10.13031/2013.17239>
- [4] Osvaldo Resende, Paulo Cesar Correa, Gabriel Henrique Horta de Oliveira, Andre Luis Duarte Goneli and Carmen Jaren Mechanical properties of rough and dehulled rice during drying, International Journal of Food Studies, Vol. 2, pp 158-166, 2013. <https://doi.org/10.7455/ijfs/2.2.2013.a3>
- [5] A. P. Tarasenko, V. I. Orobinskii, M. E. Merchalova, and N. E. Buravlev, Innovative ways of improving mechanization of high-quality seeds. Revista Ciencias Técnicas Agropecuarias, Vol 24, Iss. 2, pp. 49-52, 2015.
- [6] Zachary A. Henry, Baoyi Su, Haibing Zhang, Resistance of soya beans to compression. Journal of Agricultural Engineering Research, Vol. 76, pp. 175-181, 2000. <https://doi.org/10.1006/jaer.2000.0546>
- [7] Ebubekir Altuntas, Mehmet Yıldız. Effect of moisture content on some physical and mechanical properties of faba bean (Vicia faba L.) grains. Journal of Food Engineering, Vol.78, Iss. 1, pp 174-183, 2007. doi:10.1016/j.jfoodeng.2005.09.013
- [8] P. C. Corrêa, F. Schwanz da Silva, C. Jaren, P. C. Afonso Júnior, and I. Arana, Physical and mechanical properties in rice processing, Journal of Food Engineering, Vol. 79, Iss. 1, pp. 137-142, 2007. <https://doi.org/10.1016/j.jfoodeng.2006.01.037>
- [9] Feizollah Shahbazi, Saman Valizade, Ali Dowlatshah, Mechanical damage to green and red lentil seeds. Food Science & Nutrition 5(4), pp.943 - 947, 2017. doi: 10.1002/fsn3.480
- [10] D. N. Algazin, D. A. Vorob`ev, A. I. Zabudskij, and E. A. Zabudskaya, Povy`shenie avtomatizacii prorashhivaniya semyan [Increasing the

- automation of seed germination], Chelyabinsk: South Ural state agrarian University Publ., pp 39 –40, 2016. (in russ.) [Proceedings of the international scientific and technical conference Dostizheniya nauki – agropromy`shlennomu proizvodstvu (Achievements of science-agro-industrial production), January 2016]
- [11] V. V. Trotsenko and I. V. Trotsenko, Oczenka mashin po stepeni povrezhdeniya zerna grechikhi [Evaluation of machines for the extent of damage to buckwheat grain], Novosibirsk: Novosibirsk state agrarian University Engineering Institute Publ., pp 94 –97, 2001. (in russ.) [International Scientific and Technical Conference Mekhanizaciya sel`skokhozyajstvennogo proizvodstva v nachale XXI veka (Mechanization of agricultural production at the beginning of the XXI century), 2016]
- [12] V. V. Trotsenko, A. I. Zabudskij, and V. V. Komendantov, “Povrezhdenie zerna yachmenya mashinami pri mekhanizirovannoj obrabotke [Damage of barley grain machines for mechanical processing],” Electronic scientific and methodical journal of Omsk state agrarian University, No. 1 (8), 2017. <http://e-journal.omgau.ru/index.php/2017/1/35-statya-2017-1/783-00310>. - ISSN 2413-4066