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INFLUENCE OF MOISTURE CONTENT AND NUMBER OF MECHANICAL IMPACTS, UPON THE ENERGY AND SPROUTING CAPACITY OF WHEAT GRAINS*

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A b s t r a c t. The most frequent reason for the damage inflicted on cereal grains results from the shock and mechanical impact of harvesting, cleaning and transport. The characteristic of these processes of that the applied forces is operate in a relatively short time and change in an unpredictable way. The present research aims to define the impact of multiple loads and the moisture content of wheat grains upon the change in its biological value assessed through the energy and force of germination.

The simulation of loads was performed in a specially constructed impact unit, using the elastic deformation energy of a spring. The grains where hit, successively 1, 5, 10, 15, 20, 25 and 30 times are subjected to a germination test. The research shows a statistically significant influence of moisture content and multiple mechanic impacts upon the biological value of wheat grains subjected to dynamic loads. The implemented regression analysis shows the highest decline of biological value in the interval 1 to 20 impacts. The harvesting and post-harvest processing of wheat grains ought to be effected at a moisture content level below 18%.

K e y w o r d s: multiple mechanical loads, damages, biological value

INTRODUCTION

The most frequent reason for mechanic damage suffered by cereal grains is the shock and impact received during mechanic harvesting, purification and transport. During the mechanic impact the active forces are applied in a relatively short time. They are called the impact (impulse) forces and undergo such changes in time that they are difficult to define precisely in natural conditions. Additionally, the high variance of external conditions, such as e.g., the moisture or variety of grain, makes it difficult to analyse the real character of strains occurring in the course of grain processing.

Thus, it is necessary to simulate the strains occurring in natural conditions. The objective of the laboratory analysis of grain material lies in determining the significance mechanical of properties (resistance, hardness, elasticity, etc.) and relating these features to the observed damage [1, 2, 3]. Single strains which are applied in most cases fail to reflect properly the real strain conditions and deformations. In consequence, it is necessary to focus further analysis on multiple strains [4, 5].

The objective of the present research consisted in defining the influence of the number of impacts, and the grain moisture, upon the change in its sprouting capacity and energy.

MATERIALS AND METHODS

Grains harvested in the experimental farm RZP Rudawa were used in the research. The harvesting was done manually, and the research material was gathered in plastic bags, in order

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to preserve the stable level of moisture. As shown in Diagram 1 (Fig. 1), four varieties of wheat : Henika, Eta, Almari, and Astron, were used in the strain analysis. After the purification of collected material, a laboratory sample was impacts (Fig.1). The material strained in this way underwent a sprouting test at the Institut of Plant Raising and Acclimatization in Cracow. For each moisture level of material, seven sprouting samples were obained.

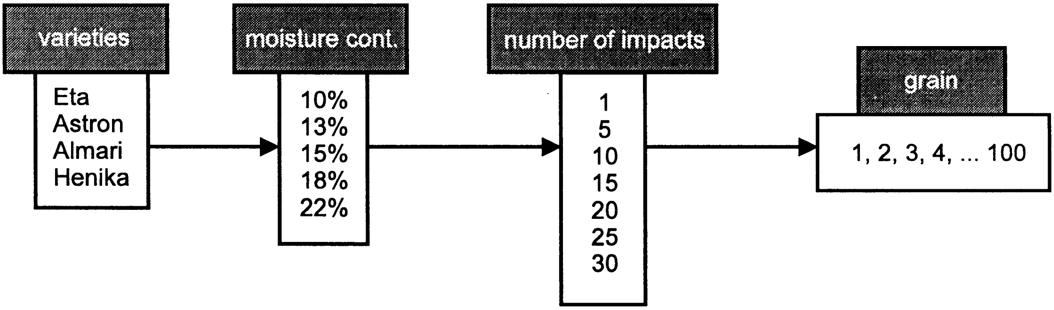

Fig. 1. Block diagram of the experiment.

separated from the mass of grain. Next, three random representative samples of 100 grains each were formed.

The material prepared as described was strained on a specially constructed beater bench, to effect "supported" impact. A diagram of this bench is shown in Fig.2. Conforming to the adopted measurement method, proposed in the paper of Ślipek *et al.* [5], a beater mass of 8 g was used, conforming to the impact energy of $4.6 \ 10^{-3}$ J.

In order to obtain the desired grain moisture levels, the material was humidified to a moisture level of 22% and, next, dried naturally. In successive versions of the experiment, the grains were subject to 1, 5, 10, 15, 20, 25 and 30

RESULTS AND DISCUSSION

In order to determine whether the number of impacts significantly influences sprouting energy and capacity, the obtained results were grouped, and, next, the mean values of sprouting energy and capacity were calculated for each combination of the experiment (Table 1).

The received data were used in two variance analyses in double classification. It was shown that both the moisture level and the number of impacts had a significant influence upon the sprouting capacity and energy value. This finding justified the application of Duncan test for both mentioned factors (Table 2 and 3). Three homogenous groups developed from the

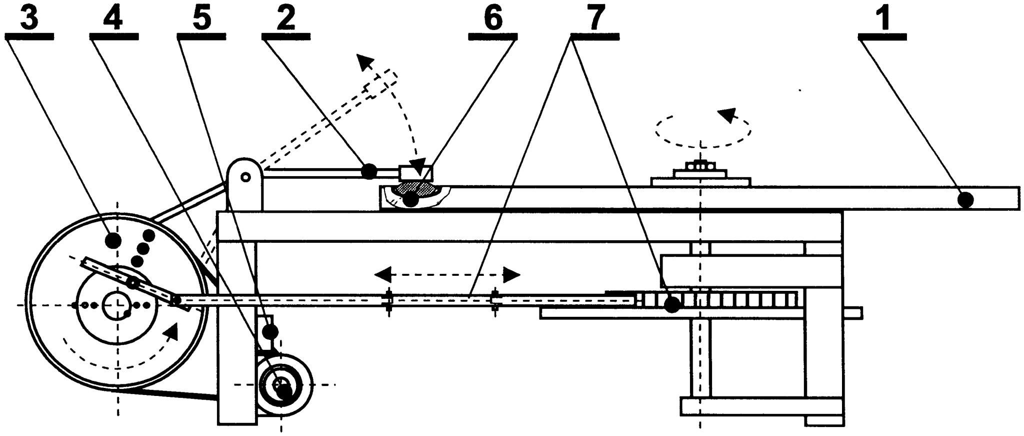

Fig. 2. Diagram of the impact apparatus: 1-rotating disk, 2-beater ram, 3-crank lever mechanism, 4-motor, 5-grain, 6-spring latch mechanism.

Table 1. The energy and sprouting capacity of wheat grain

	Moisture content									
	10%		13%		15%		18%		22%	
Number of impacts	Energy capacity	Sprouting capacity	Energy capacity	Sprouting capacity	Energy capacity	Sprouting capacity	Energy capacity	Sprouting capacity	Energy capacity	Sprouting capacity
1	98	98	95	97	94	95	96	99	90	91
5	94	96	94	98	94	94	92	92	86	87
10	94	94	94	96	92	94	90	94	84	85
15	96	97	90	94	90	94	92	92	86	86
20	98	98	93	96	88	93	82	90	80	84
25	96	96	92	94	88	95	85	87	84	84
30	95	95	93	95	90	94	86	88	83	83

Table 2. Duncan test results for sprouting energy

Factor: moisture content			Factor: impact		
Moisture content (%)	Mean value of sprouting energy	Homogenous groups	Number of impacts	Mean value of sprouting energy	Homogenous groups
22	84.14	X	20	89	X
18	89	X	25	89.8	XX
15	91.71	XX	30	90.6	XX
13	94.57	XX	10	91.2	XXX
10	97.71	X	5	92	XXX
			15	92.8	XX
			0	94.6	X

Table 3. Duncan test results for sprouting capacity

Factor: moisture content			Factor: impact		
Moisture content (%)	Mean value of sprouting capacity	Homogenous groups	Number of impact	Mean value of sprouting capacity	Homogenous groups
22	85.56		25	92.2	X
18	91.71		30	92.4	X
15	95	X	5	93.4	XX
13	97.85	XX	20	93.4	XX
10	98.57	X	10	94.4	XX
			15	94.4	XX
			1	96	X

viewpoint of sprouting energy and the moisture factor:
-moisture 10% and 13%,
-moisture 13% and 15%,
-moisture 15% and 18%.

Similarly, three homogeneous groups were found with respect to the number of impacts:
- 0 to 15th impacts,
- 5th to 30th impact (excluding the 20th),
- 5th to 20th impact.

In the case of grain sprouting capacity, higher diversification was found between the means obtained in the category of moisture levels, compared to the number of impacts. In the moisture category, four homogeneous groups were identified, while in the impact number category only two such groups were found (Table 3).

The regression analysis was run next. Two models were estimated through the least squares method :

- the linear one

$$Ew = c + bx$$

$$Zw = c + bx$$

- second degree polynomial

$$Ew = c + bx + ax^2$$

$$Zw = c + bx + ax^2$$

where Ew - the sprouting energy at given moisture level w, Zw - sprouting capacity at given moisture level w, a , b , c - coefficients.

Estimation results are shown in Table 4, and the curves of approximated values - in Fig. 3.

The analysis of obtained data indicates a tendency in the decline of sprouting energy in the course of increased impacts and growing moisture. Thus, the entire measurement zone can be subdivided into two intervals :

- the first one - 1 to 20 impacts, when the energy decline is very rapid and significant ;
- the second one - over 20 impacts, when the sprouting energy is stabilized at a certain level.

It is also significant, that - at low moisture levels - the influence of the number of impacts upon the sprouting energy is not clear. This finding is proved by the low value of coefficient a (a = 0.01 for the moisture level 13%, and a = 0.011 for the moisture level 15%). In the case of grain of 10% moisture level, a straight line with low slope to OX axis was obtained (b = 0.048).

Similar analysis was conducted for the sprouting capacity. In this case, the tendencies identified for sprouting energy were even more pronounced. The moisture range, in which the measurements were made can be divided into two intervals :

- the former one - where moisture up to 18% is included -shows a slow decline of sprouting capa- city in the course of the growing number of impacts;
- the latter one - where moisture above 18% is included -shows rapid decline in sprouting capacity in the course of the growing number of impacts.

Similarly to the case of sprouting energy, the most rapid decline in sprouting capacity occurs up to the 20th impact.

The research indicates that the harvesting and after-harvest processing of wheat grain ought to be effected below 18% moisture. It is noteworthy that the above finding does not corroborate the research results published by other authors, who advocated a moisture range 16 - 20% as optimum for harvesting. The source of this divergence probably lies in the fact that the past measurements were based mostly on single strains. As mentioned above, such conditions do no reflect properly the real-life conditions. Additionally, only the combine harvester processing was measured, without the later processing of grain which causes „fatigue". It seems that our findings ought to provide a starting point for further research, aimed at a more comprehensive reflection of real-life conditions, and the formulation of recommendations concerning the harvesting and later processing of grain.

T a b l e 4. Regession equations for the sprouting capacity and energy of wheat grain

	Sprouting energy		Sprouting capacity	
Moisture content (%)	Regression equation	R^2	Regression equation	R^2
10	$96.12 - 0.048x$	0.96	$96.79 - 0.031x$	0.89
13	$95.62 - 0.039x + 0.01x^2$	0.65	$97.94 - 0.25x + 0.005x^2$	0.60
15	$95.55 - 0.554x + 0.011x^2$	0.87	$94.91 - 0.137x + 0.004x^2$	0.49
18	$96.72 - 0.816x + 0.014x^2$	0.73	$97.92 - 0.573x + 0.008x^2$	0.82
22	$89.98 - 0.67x + 0.015x^2$	0.68	$90.46 - 0.521x + 0.01x^2$	0.87

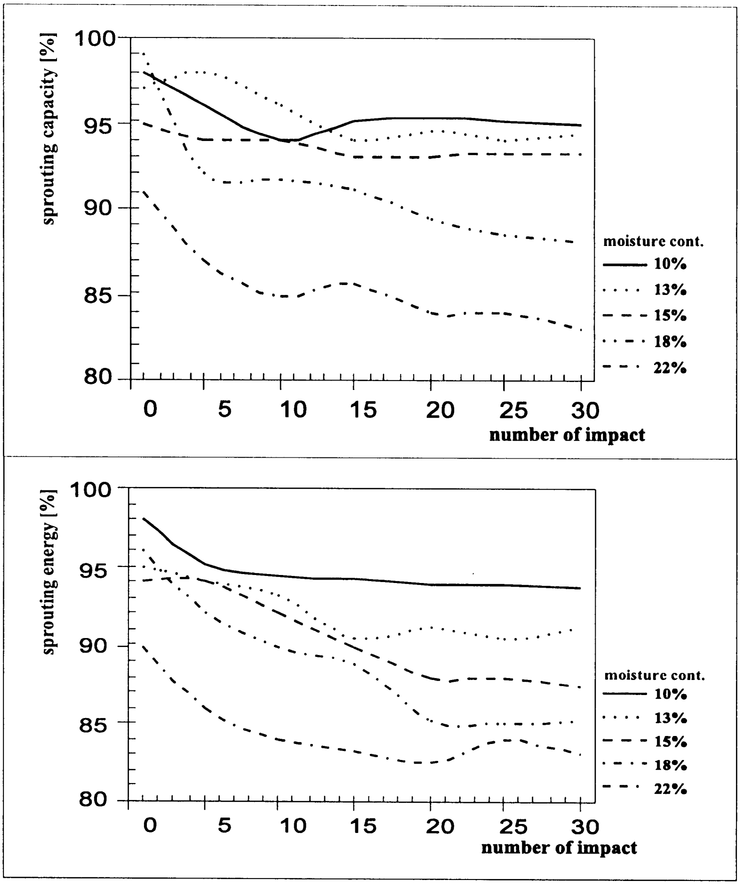

Fig. 3. Sprouting capacity and energy for various moisture content level.

CONCLUSIONS

1. A significant relation was found between the grain moisture content /number of impacts and the biological value of wheat grain subjected to multiple dynamic strains.

2. The most significant decline in energy and sprouting capacity occurred in the interval between 1 and 20 impacts.

3. At low moisture content of grain, the influence of the number of impacts upon the sprouting capacity and energy is lower than it is in the case at moisture content levels higher than 18%. Therefore, the harvesting and post-harvest collection of wheat grains ought to occur at moisture content levels lower than 18%.

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