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SUSCEPTIBILITY OF RAPE SEEDS TO DYNAMIC DAMAGES DEPENDING ON MOISTURE AND STORAGE TIME*

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A b s t r a c t. Mechanical properties of winter rape seeds were estimated. Investigated seeds were subjected to various dynamic loads using a measuring stand, whose design and methodical assumptions allowed us to stimulate dynamic loads typical for agricultural threshing and transport machines. In order to determine the influence of moisture on the strength characteristics of seeds, they were moistened for a second time in a 'Weiss' climatic chamber. The influence of seeds storage period on their dynamic resistance was estimated. Therefore, fresh-picked and stored for 8 months seeds were used.

The studies showed that there is a relationship between the seeds moisture level and their resistance to dynamic loads. Seeds with 6 % moisture loaded with energy of 1 mJ contained 100 % of damages, while the same amount of energy in the sample with 15 % moisture caused only 20 % of damage. Time of storage also affects the strength features of seeds. The seeds tested directly after they had been picked had damage resistance several times higher than the same seeds after a long period of storage with similar moisture during test performance.

K e y w o r d s: rape, seeds, dynamic loads, damage

INTRODUCTION

Dynamic interactions which appear between the seeds and the elements of machines and tools during harvest, transport and storage processes have an important influence on the rate and the character of damage to rape seeds [1]. The extent of macro- and microdamage depended on harvester working parameters - rotation of the beater drum and the gap between the drum and the concave [2]. Such seeds, even entire seed lots (in which the damaged seeds occur) possess lower technological value, especially when they are intended for storage [4]. During long storage the chemical composition of the seeds changes significantly. The character of these changes probably influences also their mechanical strength. Therefore, it is interesting to know the influence of moisture and storage period not only on the chemical composition of seeds, but also on their strength features, especially the resistance to mechanical loads of dynamic origin. Only the seeds which contain the whole set of favourable chemical and mechanical parameters are a valuable resource with high use values for the fat industry.

THEORETICAL BASIS

The impact phenomenon is caused by at least two bodies hitting each other with different velocities (rape seed - beater drum, conveyor, chute, etc.). Forces which are activated at the moment of collision are called instantaneous forces. These forces last for a very short period of time and reach high values. When the seeds hit an obstacle they have to equalize their velocities. If the bodies hitting each other were ideally rigid, equalizing the velocities

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should be done in an infinitely short time and, thus, the force should be infinitely high. Elastically deformed bodies recuperate to their original shape after the disappearance of acting forces, while elasto-plastic or plastic bodies preserve the deformed shape. Work used for elastic deformation becomes potential energy (elastic) and work used for plastic deformation usually becomes heat or, in the case of rape seeds, destroys the seed, i.e., it overcomes the cohesion forces of the seed tissues. At the moment when a seed hits an obstacle (treated as straight and central impact, Fig. 1) instantaneous forces $\bar{P}$ and $(-\bar{P})$ appear. They influence both bodies and cause changes in mass momentum m_1 of the seed and m_2 of the obstacle [1]. The value of the instantaneous force $\bar{P}$ changes in time and increases from the moment t=0 to the t_1, that is the moment of maximum deformation of seeds. It is illustrated by the following relation:

$$\int_0^{t_1} \bar{P}dt = m_1\bar{u} - m_1\bar{v}_1 = m_1\,(\bar{u} - \bar{v}_1) \qquad (1)$$

where m_1 is mass of rape seeds, $\bar{v}_1$ - initial velocity of rape seeds at the moment of hitting the obstacle (t=0), $\bar{u}$ - collective velocity of rape seeds and the obstacle after the time t_1 (terminal velocity), and $\bar{P}$ - value of the instantaneous force influencing the seeds.

During the impact, until the velocities equalize, kinetic energy E and potential energy V of the hitting body (seeds) decrease - part of energy changes into heat. This energy, also called the impact energy E_u, equals the work of instantaneous force $\bar{P}$ on the distance s of the deformation of both bodies (in our case it concerns mainly the seeds):

$$E_u = \frac{1}{2}m_1\,(v_1^2 - u^2) + V = \int_0^{s} \bar{P}ds \qquad (2)$$

Kinetic energy of the seeds used for deformation heat or for the damage of seeds is called the lost energy E_s, which has, after some changes, the following value:

$$E_s = \frac{1}{2}\,(1 - k^2)\,m_1\,v_1^2 \qquad (3)$$

where k is the seed reflection coefficient $0 \leq k \leq 1$, (k=0 - ideally plastic bodies, k=1 - ideally elastic bodies), m_1 - mass of rape seeds, v_1 - velocity of a rape seed at the moment of hitting the obstacle, and with the assumption that the potential energy gain equals zero (V=0), v_2=0 - velocity of the obstacle and the mass of the body under impact (the obstacle) $m_2 > m_1$ of the seed.

The formulae above (1,2, and 3) indicate that:

- the value of the instantaneous force $\bar{P}$ (damaging the seeds) depends, in direct proportion, on the mass of the seeds. For

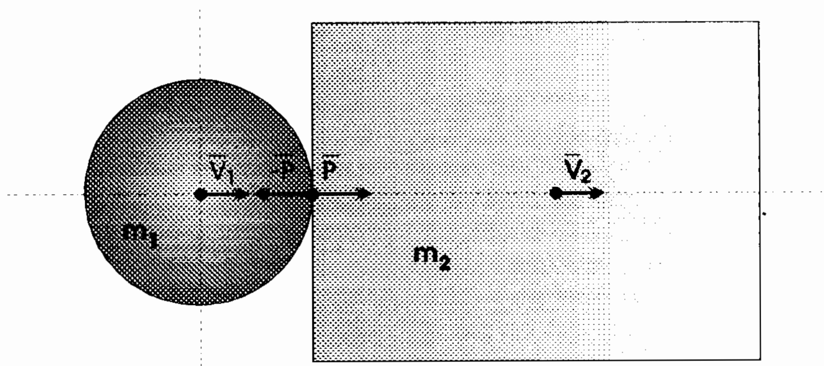

Fig. 1. Straight and central impact of two bodies.

example, the impact of two rape seeds of different masses by the beater drum (assuming that the rotation velocity of the beat drum is constant) would damage the seed with greater mass more than the seed with smaller mass;

- the value of the instantaneous force depends in direct proportion on the difference of velocities (u - v_1). Seeds with the same mass falling against a motionless obstacle with different initial velocities will have different probabilities of getting damaged. More likely to get damaged are the seeds with greater initial velocity v_1;
- seeds with low reflection coefficient k (e.g., dry, not very elastic seeds) are more exposed to dynamic damage.

METHODS

The studies were carried out at the Institute of Agrophysics in Lublin, on a special measuring stand. The design and methodological features of that stand allowed for simulation of dynamic loads in a wide range. Fresh-picked rape seeds of the Ceres variety, fraction 2.0, were used for the investigation. In order to estimate the influence of moisture on seed strength features, the seeds were moistened artificially in the 'Weiss' climatic chamber. Seed moisture obtained in that way ranged from 5.5 % to 24 %. At the simulation stand the impact energy was used in the range from 0.35 to 1.8 mJ, which matches the dynamic load abilities of rape seeds close to the drum of a harvester during its work.

The same rape variety was used for the investigation after 8 month-storage at the moisture of 5.7 %. In each case, 100 seeds were taken for the tests.

RESULTS

The results obtained indicate that there are differences in seed resistance to impact depending on the moisture of a seed (Fig. 2). It particularly concerns the seeds loaded with greater impact energy E.

For the seeds loaded with the energy E=1.8 mJ, 60 % of the seeds with 24 % moisture were damaged, while the seeds with 5.5 % moisture had almost 100 % of damage. An increase in seed moisture changes its resistance coefficient k. Thus, the seed absorbs more impact energy and changes it to heat, for instance. Seed tissues become more elastic and susceptible to deformation.

Special attention should be given to the fact that impact resistance of seeds stored for a long period of time was significantly lower (Fig. 2). Rape seeds stored in a sack for 8 months showed much lower resistance than rape seeds investigated right after cropping, with similar moisture. Even the impact energy of 1.0 mJ damaged 100 % of the seeds.

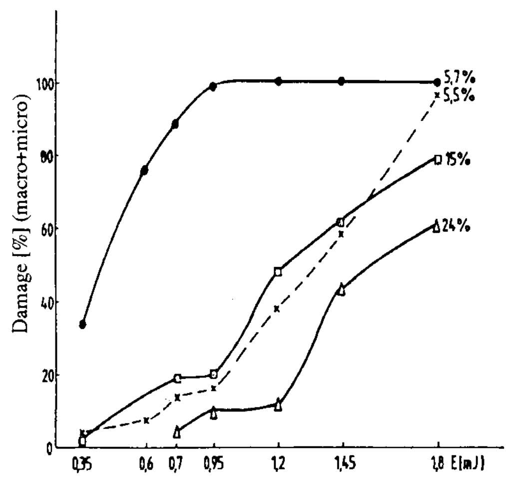

Fig. 2. Influence of impact energy, moisture, and storage time on the extent of damage in rape seeds (fraction 2.0). Solid line - 8 moths after harvesting, dashed line - 1 month after harvesting.

This phenomenon is undoubtedly related to biological processes which decrease the strength of cell walls of a seed and should be known to users and to service staff who take care of the storage and processing of rape seeds.

CONCLUSIONS

1. The studies confirmed the significant differences in rape seed resistance depending on the impact energy, moisture, and storage time.

2. Research should be continued taking into consideration other rape varieties. Final result of such research could be a service manual for the users of agricultural machines. Such instruction would include, for example: setting the maximum rotation speed of harvester beat drum according to the moisture of rape seeds harvested.

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PODATNOŚĆ NA USZKODZENIA DYNAMICZNE NASION RZEPAKU W ZALEŻNOŚCI OD WILGOTNOŚCI I CZASU PRZECHOWYWANIA

Dokonano oceny właściwości mechanicznych nasion rzepaku ozimego. Badane nasiona poddano zróżnicowanym obciążeniom dynamicznym wykorzystując do tego celu stanowisko pomiarowe, którego konstrukcyjne i metodyczne założenia dają możliwość symulacji dynamicznych obciążeń spotykanych w rolniczych maszynach młócących i transportujących. W celu określenia wpływu wilgotności na cechy wytrzymałościowe nasion dokonano wtórnego (sztucznego) ich nawilżenia w komorze klimatyzacyjnej 'Weiss'. Określono również wpływ czasu przechowywania nasion na ich wytrzymałość dynamiczną. W tym celu do badań użyto nasion bezpośrednio po zbiorze oraz po ośmiomiesięcznym ich przechowywaniu.

Badania wykazały zależność między stopniem wilgotności nasion a ich odpornością na oddziaływanie dynamiczne. Nasiona o wilgotności 6 % obciążone energią ok. 1 mJ zawierają 100 % uszkodzeń, natomiast ta sama energia w próbce o wilgotności 15 % powoduje jedynie 20 % uszkodzeń. Czas przechowywania również wpływa znacznie na cechy wytrzymałościowe nasion. Nasiona badane bezpośrednio po zbiorze charakteryzowały się kilkakrotnie wyższą odpornością na uszkodzenia w porównaniu do takich samych nasion po długim czasie ich przechowywania przy porównywalnych wilgotnościach w czasie badań.

S ł o w a k l u c z o w e: rzepak, nasiona, obciążenia dynamiczne, uszkodzenia.