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RESISTANCE OF RAPE SEEDS TO THE IMPACT OF DYNAMIC FORCES*

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A b s t r a c t. Results of investigations on the susceptibility of rape seeds to macro- and microdamage caused by the dynamic contact between seed and metal are presented in this paper. The damage is understood as a disturbance of the continuity of seed tissues as a result of the impact of external mechanical factors. The presence of the damage may cause the initiation of unfavourable chemical and biological reactions inside seeds and, as a consequence, can cause the decrease of their technological and reproductive values.

The investigations were carried out with four winter rape varieties taking into consideration the size of seeds, point and energy of impact. An evaluation of macro- and microdamage was made with the method elaborated earlier at the Institute of Agrophysics in Lublin.

The investigations show that varietal features significantly differentiate the resistance of seeds to damage. From among varietes under investigation the least resistant to impacts appeared to be Mar and the most resistant - Ceres. It was also found that the point of impact in seed has significant effect on its resistance. It is markedly visible with the smallest seeds (fraction 1.8 mm). Seed damage was evaluated in dependence on a wide range of impact energy (from 0.3 to 1.8 mJ).

The results obtained show that small seeds undergo greater damage in comparison to larger ones. It is more visible at higher ranges of impact energy.

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

INTRODUCTION

Technology of obtaining and preparation of rape seeds for processing includes many elements when seeds are subjected to the action of dynamic forces. The first contact of seeds with vibrating elements of machines occurs in the moment of threshing. Experimental results showed that according to the technology used (especially with two-stage harvesting when seed moisture is below 10 %), the rate of damage (macro and micro) can reach a value from a few to more than ten percent. Threshing drum speed and also the moisture of seeds play a decisive role in this situation.

An important role is also played by the genetic factors which are coded in the individual varieties [2-4]. Later contact of seeds with dynamic load is the result of transport and other operations (cleaning, drying) when whole lots of seeds dried to 4-6 % (hence very susceptible to even the slightest impact), are subjected to further load in conveyors and feeders. So, before seeds get to silos for longer storage, they are subjected for several times to different dynamic load which cause their damage. Their contact with 'healthy' seeds causes an increase of chemical and biological activity (respiration, oxygenation, development of microorganisms) of the whole lot of raw material, thus decreasing its technological value. This is a reason to look for factors which determine

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the resistance of seeds to the impact of dynamic forces.

Taking into consideration the morphological and anatomical structure of rape seeds in connection with their mechanical strength may give a new look on the formation of seed damage and its interpretation.

EFFECT OF RAPE SEEDS STRUCTURE ON THEIR DYNAMIC RESISTANCE

The shape of rape seed is ellipsoidally spherical with the diameter of 2-3 mm. On its cross-section (Fig. 1 [1]) an external seed cover, commonly named hull, is visible. Under the cover there are remains of one-layered endosperm filled with aleuronic grains. Inside the seed there is a big nucleus with two unequal seed leaves, from which the external one nearly entirely embraces the internal. The bent

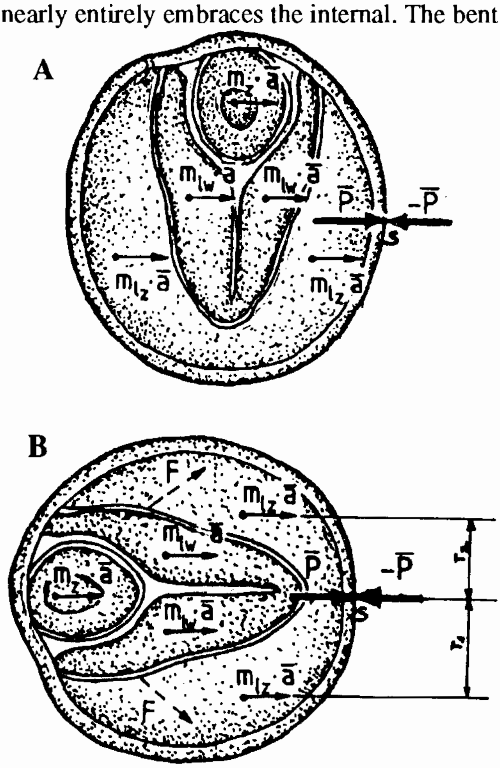

Fig. 1. Orientation and forces at the moment of striking rape seed: a - perpendicular impact to the plane dividing grain across the germ and points of narrowing seed leaves - position A; b - impact in the point of narrowing seed leaves - in the plane crossing the germ and points of seed leaves narrowing - position B.

axis of the germ, composed of primordial root and hypocotyl, slightly sets off outside. Such a structure of rape seeds determines their differentiated shock resistance in relation to the point of force application on the seed surface.

Lets consider now two possible seed orientation A and B in relation to the obstacle at the moment of striking (Fig. 1). In both situations, when a rape seed meets an obstacle, it is deformed in relation to the force:

$$P = f(m, a) \quad (1)$$

where a - acceleration, m - mass of seed, but:

$$m = 2\, m_{lz} + 2\, m_{lw} + m_z \quad (2)$$

where m_{lz} - mass of a half of external seed leaf, m_{lw} - mass of a half of internal seed leaf, m_z - mass of germ.

After some simplifications the equation of equilibrium for both events is:

$$\bar{P} = m_z \bar{a} + 2\, m_{lw} \bar{a} + 2\, m_{lz} \bar{a}\,. \quad (3)$$

In orientation A (seed strikes an obstacle with the side surface of seed leaf), a mutual approach of seed leaf lobes appears during the strike. This is a favourable phenomenon because the internal movement plays a shock absorbing function, alleviating the effects of the strike.

In case of an increase of the slit between seed leaves (dry seeds) and stiffening of their tissues, a concetration of stresses in the zone of seed leaves bending will appear, caused by the moments of bending coming from forces: $m_{lz} \bar{a}$ and $m_{lw} \bar{a}$.

In orientation B of the seed, apart from compressed stresses in point s coming from the force $\bar{P}$, additional stresses coming from the action of bending moments of external seed leaves appear: $m_{lz} \bar{a}\, r_1$ and $m_{lz} \bar{a}\, r_2$.

Bending moments of the internal seed leaf play a less significant role because $m_{lw} \bar{a}$ forces are much smaller and operate on shorter arms. In struck seed with such an orientation the external seed leaf and the germ will try to move towards point s and, acting as a wedge, will cause that the external seed leaf will be affected by forces *F* which will try to 'straighten' it, thus causing an additional increase of stresses in the surroundings of point s of the external seed leaf (Fig. 1).

As follows from the above, a strike of a rape seed with B orientation gives a greater possibility of its damage than in A orientation at the same striking energy.

LABORATORY EXAMINATIONS

The investigations were to give an answer to the following questions:

- Does the orientation of rape seed at the moment of striking affect its dynamic resistance?
- Whether and in which range rape variety and size of seeds affect their dynamic resistance?

The investigations were carried out with the use of a stand designed at the Institute of Agrophysics in Lublin. This stand gives the possibility of dynamic simulation of loads met in agricultural threshing machines. The stand, apart from the simulation of impact energy, also permits any seed orientation with regard to the surface of the striking beater.

Seeds of four rape variaties: Liporta, Ceres, Bolko and Mar were taken for examination in the phase of full ripeness. Moreover, seeds of the Liporta variety were taken five days before full ripeness. The moisture of seeds was from 5 to 6 %. They were divided into 3 fractions according to diameters: I - 1.8 mm, II -2.0 and III - 2.3 mm.

RESULTS

The results obtained (Fig. 2) show that there exists a distinct difference in the resistance to damages of rape seeds of all varieties examined, which depends on the point of impact on the seed. This difference is visible especially with smaller seeds (fraction 1.8 mm). With larger seeds this difference (between positions A and B) is smaller, but with the Liporta variety it reaches 300 %. The lower

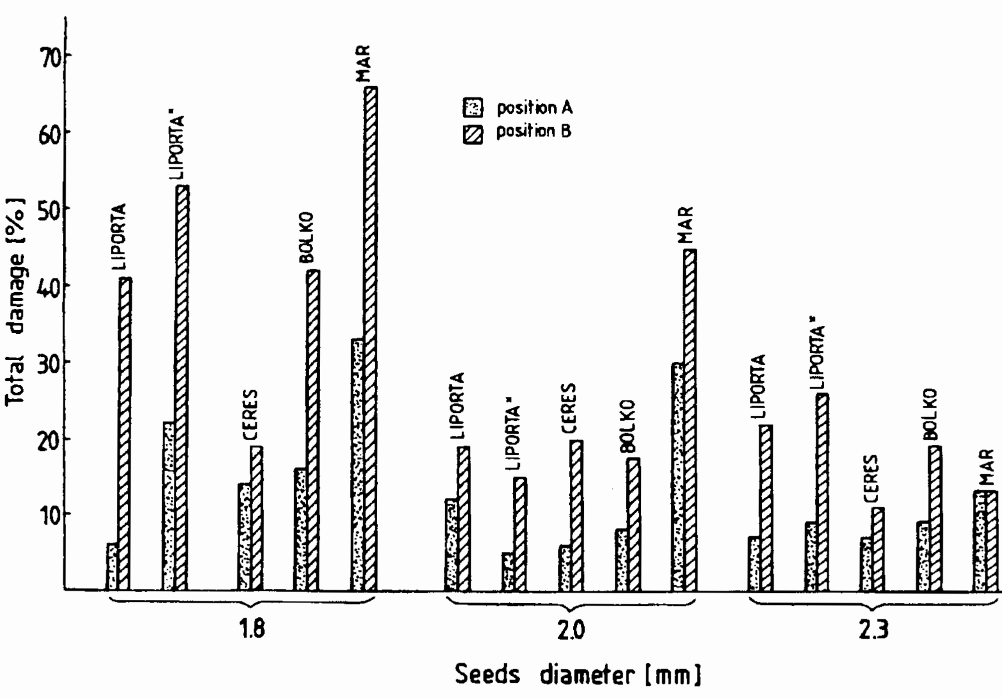

Fig. 2. Graphic presentation of the extent of seed damage for the varieties under study (E = 400 μJ).

resistance of small fraction seeds to striking can be explained by their anatomical structure (smaller seeds cannot yet be mature and can be characterized by not too strong seed cover, less narrow seed leaves, etc.). Some influence is also extended by the smaller radius of curvature of small seeds. Hence, smaller contact area between the seed and ram and, as a result, greater local stress. This hypothesis can be confirmed by results for the Liporta variety whose earlier harvest decreased seed resistance to impact.

CONCLUSIONS

1. The point of impact of rape seed affects its mechanical resistance.

2. The dynamic resistance of rape seed is also dependent on the size of seed, its maturity and variety of rape.

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ODPRNOŚĆ NASION RZEPAKU NA DZIAŁANIE SIŁ DYNAMICZNYCH

W pracy przedstawiono wyniki badań dotyczące podatności nasion rzepaku na makro- i mikrouszkodzenia wynikłe z dynamicznego kontaktu nasiono-metal. Uszkodzenia te rozumiane są jako naruszenie ciągłości tkanek nasion w wyniku oddziaływania zewnętrznych czynników mechanicznych. Obecność tych uszkodzeń może mieć wpływ na inicjację niekorzystnych przemian chemicznych i biologicznych w nasionach a w konsekwencji może spowodować obniżenie jego wartości technologicznej i reprodukcyjnej.

Badania przeprowadzono na czterech odmianach rzepaku ozimego biorąc pod uwagę wielkość nasion oraz miejsce i energię uderzeń. Oceny makro- i mikrouszkodzeń dokonywano według metodyki opracowanej wcześniej w Instytutcie Agrofizyki PAN w Lublinie.

Przeprowadzone badania wskazują, że cechy odmianowe istotnie różnicują odpomość nasion na uszkodzenia. Z badanych odmian najmniej odpomą na uderzenia okazała się odmiana Mar, natomiast najbardziej Ceres. Stwierdzono również, że miejsce uderzenia w nasiona ma bardzo istotny wpływ na ich wytrzymałość. Najwyraźniej jest to jednak widoczne u nasion najmniejszych (frakcja 1,8 mm). Uszkodzenia nasion oceniano w zależności od szerokiego zakresu energii uderzenia (od 0,3 do 1,8 mJ).

Uzyskane wyniki wskazują, że nasiona małe ulegają większym uszkodzeniom w porównaniu do nasion większych. Uwidacznia się to szczególnie wyraźnie przy wyższych zakresach energii uderzenia.

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