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Estimation of physical results of percussive loads in wheat and triticale seed

G. Szwed and J. Tys

Institute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, P.O. Box 201, 20-290 Lublin 27, Poland

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A b s t r a c t. This paper contains the evaluation of the physical effects of impact loads on wheat grain and triticale one. One level of kinetic energy (15 mJ) exerted on the tested grain had already been established. The point of impact for these forces was the dorsal side of the grain. The physical effects of the action of these impacting forces on the tested grain were evaluated by means of visually analyzing X-ray images before and after impact. Results of this research show that wheat grain has a higher resistance to impact loads, for example during combine harvesting, then does triticale one.

K e y w o r d s: seed, damage, impact, triticale, wheat

INTRODUCTION

This paper reviews the estimation of the vulnerability of common wheat seeds to micro- and macroinjures due to dynamical contact between seeds and metal. Such injures are thought of as breaks in grain tissue continuity as result of the grains' interaction with outer physical factors.

Apart from the loss of seed mass, these injuries can also affect the initiation of unfavorable chemical and biological changes within seeds; consequently, they can cause a decrease in their technological and reproductive value. These broad problems are discussed in publication written by Kolowca [2] and Strona [4].

Many seed injures are due to forces stemming from the moving parts of various technological processes – harvesting, threshing, purification, transport, etc. There are however noted, cases of injury to seeds still located in the spice.

This is probably due to sudden air temperature and humidity changes during seed maturation [1]. The type and range of injuries caused by rotating machine elements mainly depends on a grain's morphological and anatomical structure – size and shape, seed thickness and fruit cover, and density [2,5,6]. The seed's water content is also of great importance. According to numerous studies, there is an optimum water content for each variety in which a seed is least vulnerable to injuries from outer mechanical loads [2,4]. The effects of the mineral fertilization level is also worth mentioning [1]. It is very important to use injury – minimizing harvesting techniques and to further introduce varieties and agrotechnical methods that ensure the maximum resistance to injury [3].

The simulative studies on dynamical injuries were carried out to verify the following hypotheses:

1. Seeds of various wheat and triticale varieties differ in their resistance to impacts. Resistance to impacts can be advantageous (storage, biological form). On the other hand, high impact resistance is an unfavorable trait in processing (comminution) because of higher energy costs and less efficiency in size reduction.

2. The dynamical resistance of grain depends on the point of impact. Previous investigations using rape seeds prove this hypothesis [5].

3. Dynamical impacts affect the internal micro-cracks in seeds (invisible to the naked eye). The number of internal micro-cracks has a significant effect on the decrease in a seed's resistance to injuries. Internal micro-cracks formed during maturation (temperature or humidity gradient) lower a seed's internal compactness and may reduce its dynamical strength. In turn dynamical impact may affect the increase in internal micro-cracks.

MATERIAL AND METHODS

Common wheat and triticale lines produced at the Institute of Genetics and Plant Breeding, University of Agriculture in Lublin (CZR 1248, CZR 1334, CZR 1406,

*Corresponding author's e-mail: gszwed@demeter.ipan.lublin.pl

CZR 1277) as well as the varieties Jana, Lanca, and Presto were used for simulative studies on dynamical injuries. The grain was removed from the spikes by hand (Fig. 1).

Two groups of 100 seeds for each of the particular varieties and lines were used: A – for head impact, B – for convex impact (Fig. 2). The simulation stand made at the Institute of Agrophysics, Polish Academy of Sciences, Lublin, was used for the investigations. The stand simulates seed impact on an obstacle. At the moment of impact a seed's kinetic energy in equal to:

$$E = mV^2 /2 \ \ (\mathrm{J})$$

m - grain weight (kg), V - linear velocity of grain (m s^{-1}).

Roentgenographical investigations were carried out using an ELEKTRONIKA 25 apparatus to estimate internal injuries in seeds. The X-rays passing through the examined seed is absorbed by damaged and healthy parts of the seed in different amounts. Non-damaged parts strongly absorb the radiation which gives a bright picture on a photographic plate. X-rays passing through the damaged areas are slightly absorbed producing dark spots [3].

Seeds (100 per sample) were adhered to filter paper in a 'furrow down' position and exposed to X-rays within 8 hours. Pictures with a 2:1 graduation were obtained on the photographic plate. The mechanical injuries of seeds appeared on roentgenograms in various ways. Internal cracks and slits were visible as very sharp, dark shadows located mainly perpendicularly to the furrow. There were also parallel cracks formed due to axial force action as well as 'star-like' cracks due to the point – wise application of force. The weak side of this method is that slight changes in grain position in relation to the direction of the X-rays causes the pictures of some injuries to change their shape, size, and arrangement. Some even become invisible.

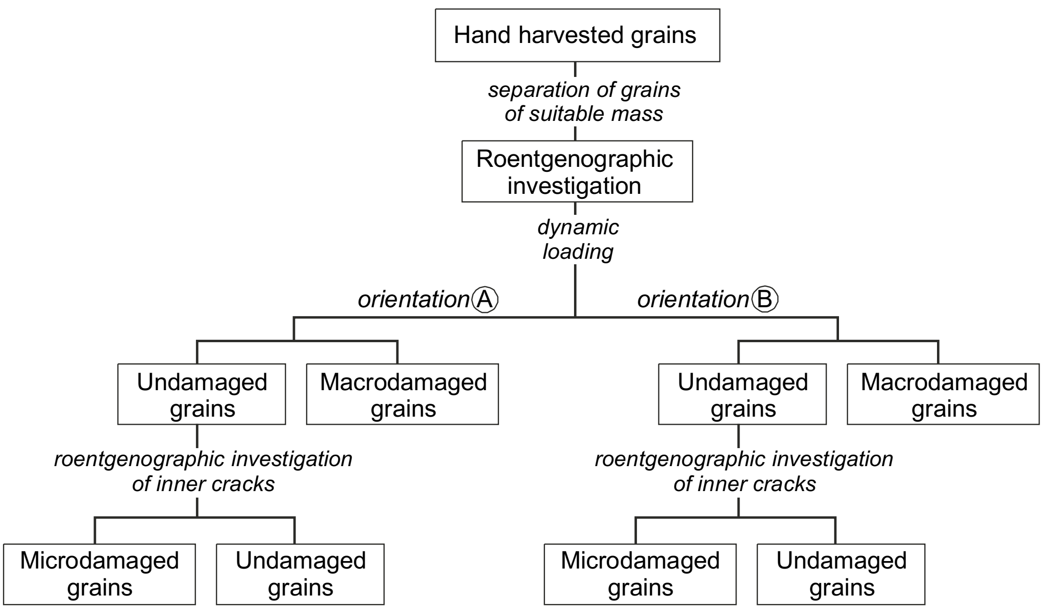

Fig. 1. Scheme stage of investigation.

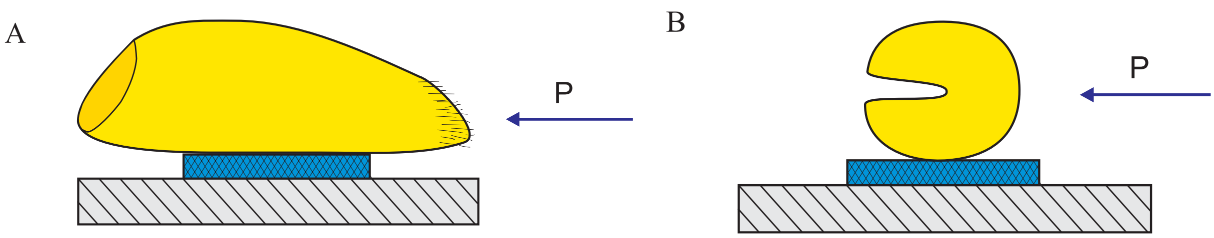

Fig. 2. Areas of impact on wheat grain under dynamic investigation. A – impact on brush, B – impact on back.

RESULTS

The imitative studies were carried out under laboratory conditions using a stand applying the following rules:

- It was generally accepted for all seeds that at the moment of contact with an obstacle, the seeds had the same kinetic energy – 15 mJ, no matter their position;
- In both of the positions considered, the seeds were hit with a flat surface and the weight of the beater was many times greater than that of the seed.

The course of the whole study process is presented on Fig. 2.

Micro-cracks in investigated seeds were analyzed by dividing the grain into three equal, linear zones (with planes perpendicular to its longer axis):

zone 1 – section of the grain with the germ,

zone 2 – middle section of the grain,

zone 3 – section of the grain with its head.

Detailed results are presented in Table 1 and in Fig. 3.

T a b l e 1. Results of estimating wheat grains damage

Cultivar line	Groups of grains	Grains after impact				
		Coefficient of suceptibility to microdamage (*k*)				Number macrodamage (%)
		Zones			Sound grain	
		I	II	III		
Jana	A	1.1	1.0	1.1	1.1	4
	B	1.0	1.0	1.1	1.1	16
Lanca	A	0.6	0.6	0.7	0.7	1
	B	0.6	0.4	0.5	1.6	8
CZR 1248	A	0.5	1.2	1.1	1.2	2
	B	0.4	1.8	1.2	1.3	13
CZR 1334	A	8.5	1.1	5.5	3.1	0
	B	4.0	0.8	6.5	2.2	9
CZR 1406	A	2.5	1.5	15.0	1.7	8
	B	1.2	1.0	11.5	1.2	15
CZR 1277	A	1.0	1.0	1.0	1.0	0
	B	0.7	1.0	0.9	1.1	7
Presto	A	1.0	2.3	2.0	1.6	2
	B	1.3	1.8	0.7	2.9	40

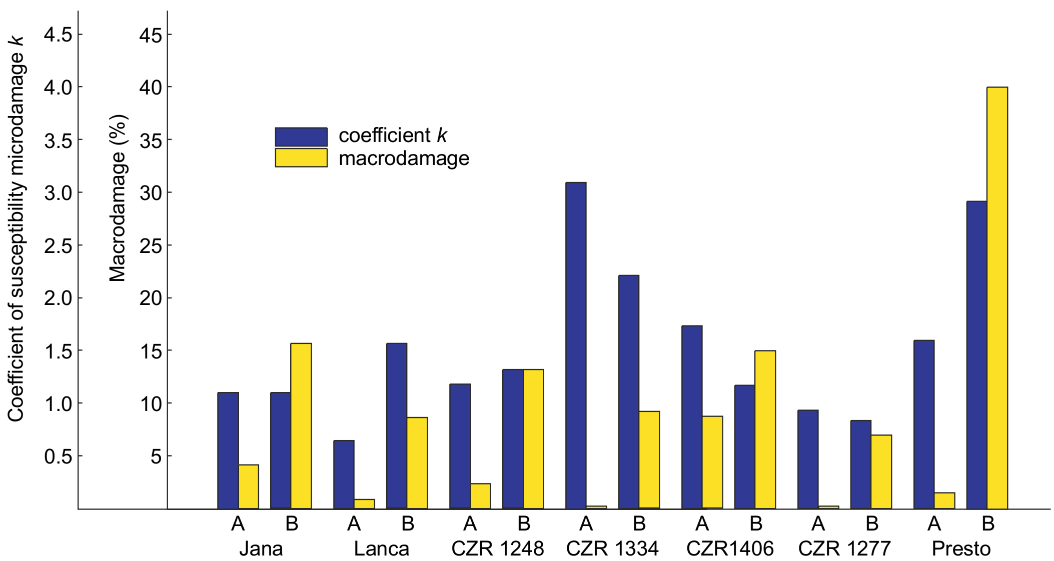

Fig. 3. The influence of dynamic loading (E=15 mJ) of wheat grains on grain damage. A – grains impacted on brush, B – grains impacted on back.

To estimate how seed impact affects the formation of micro-injuries, the concept of the vulnerability coefficient to micro-injuries *k* was introduced. It can be useful for estimating micro-injuries in the seed zone in question or in the entire seed. The coefficient is expressed as:

$$k = \frac{\text{percentage of seeds with micro-injuries after impact (in a zone or entire seed)}}{\text{percentage of seeds with micro-injuries before impact (in a zone or entire seed)}}$$

When $k>1$, dynamical loads had a significant effect on the formation of new micro-injuries. When $k<1$, micro-injuries present before impact had an effect on the formation of macro-injuries (seeds were already weakened and they crumbled), and there was a slight effect of dynamical loads causing new micro-injuries.

CONCLUSIONS

The studies conducted bring together the following conclusions:

1. The method of the described impact studies is useful for estimating seed vulnerability to dynamical loads.

2. All studied varieties and lines had different resistance depending on the site of grain impact. The convex impact was the most unfavorable. All grains showed the least resistance in this impact position.

3. At the second stage of this study, large differences did not occur. Line CZR 1248 was the most resistant to macro-injuries.

4. The highest increase in micro-injuries took place in zone 3 of Jana (wheat) as well as in zone 3 of Presto (triticale). In most cases, higher increases in micro-injuries were observed for zone 3. Overall, the highest increase in micro-injuries was found in Jana, Lanca and Presto.

5. The percussive simulative tests should be continued in order to learn the relationship between the energy value and impact site, and the effect of this relationship on seed repro- ductive value, especially when the impact is near the germ.

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