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SOURCES AND CAUSES OF RAPE SEED DAMAGE DURING COMBINE HARVESTING*

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A b s t r a c t. Areas were marked in Bizon-Super grain combine-harvester, from which sampling of rape seed was made to determine the sources of seed damage. This was done in such a manner that the results obtained could clearly define the effect of different combine assemblies and their parameters on the degree of damage of rape seeds.

The evaluation of damage concerned seeds which consisted representative sample of the whole lot of seeds uptaken from the individual measurement points, at random, with division into macro- and microdamage as well as halves of seeds.

The investigations were carried out during three successive years on seven varieties of winter rape. In this paper the distribution of damage which appear in the chosen combine assemblies, at different parameters of their work and in two cropping terms is presented.

K e y w o r d s: winter rape, combine harvesting, seed damage

INTRODUCTION

New varieties of winter rape are characterized by an increased susceptibility to losses and damage during combine harvesting [1,3,4]. During the estimation of raw material provided to purchasing points and grain storage facilities the occurrence of considerable quantity of damaged rape seeds is being observed. The magnitude of the damage has a great effect on the course of storage and processing and also on the quality of products obtained.

METHODS

To identify the sources and causes of seed damage in the Z056 Bizon-Super grain combine harvester, 5 areas inside the combine were selected. From these places sampling was made, so that the results obtained could clearly define the effect of different combine assemblies and their parameters on the degree of damage of rape seeds and also seed damage in the canopy immediately before harvesting [2]. The areas chosen were marked with letters shown in Fig. 1.

The experiments were carried out with 7 rape varieties (Ceres, Bolko, Mar, Liporta, Libravo, Leo, Polo) in 3 years' cycles in optimal and delayed cropping time. Damage estimation was performed on seeds which constituted sample of the whole lot of seeds uptaken from separate measurement points of random, in accordance with the obligatory standards, using a palette with drilled holes, designed for this purpose. Then seeds with visible damage (with defects and also with damaged seed cover) as macrodamage, were separated. Remaining seeds were treated with water with the addition of detergents (to accelerate swelling). Cracks and damage not seen before, were observed

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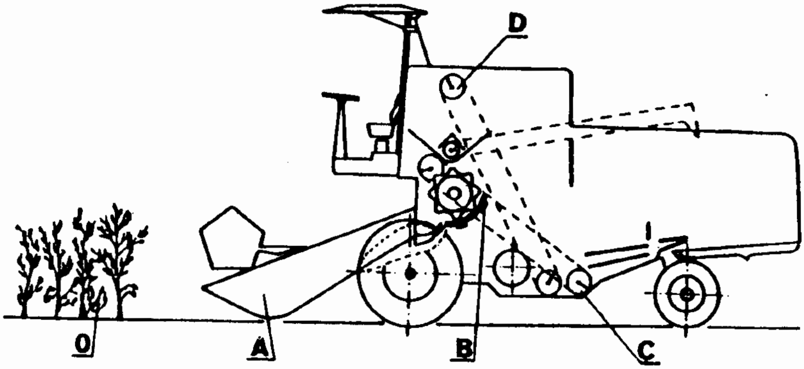

Fig. 1. Areas of sampling for the determination of rape seed damage: 0 - canopy, A - header, B - threshing unit, C - ear conveyor, D - container.

after 15-20 min. The separation of these damaged seeds from healthy ones is easier because of the difference in colour. This difference occurs between the black cover and the yellow part of the seed cotyledon. This makes it easy to notice even the smallest cracks which can be classified as microdamage. The quantity of half seeds was determined separately. They were marked as halves.

To determine seed damage in the canopy, siliques were collected in the field and threshed by hand. Each experimental combination was represented by results from 10 samples with 100 seeds each, taken randomly.

RESULTS

The extent of seed damage, in percentages which appeared in the chosen measurement places, in conditions of the optimal tuning of the working units of the combine (beater bar drum - 600 r.p.m., fan - 600 r.p.m., slot - 16 mm) and optimum harvest time is shown in Table 1.

The appearence of seed damage for all cultivars in the canopy (see p. 0) was noted still before the harvest (Table 1). Most of the damage was of micro- and macrocharacter.

Table 1 also shows that the extent of the damage in samples taken from the floor of the header (see p. A) slightly exceed the level of damage observed for different cultivars in the canopy.

In the canopy as well as in the header macro- and microdamage predominate. Increase in their level is the result of the effect of the active canopy divider, the cutting unit and the auger-and-finger feeder.

The main source of rape seed damage is the threshing unit of the combine. Samples which were taken under the thresing concave (see p. B) in its outlet part show that the total amount of damaged seeds in this unit reaches 7.6 %. The high velocity of rotary motion of the working elements of the threshing drum is the cause of the damage.

In the cleaning assembly of the combine there occurs a distinct separation of seeds in the air stream from the fan due to transmission of damaged seeds (especially halves) to the tailings auger, and as a result the return of these damaged seeds to the entrance of the threshing unit. The amount of damaged seeds increased behind the threshing drum in the main technological line (Fig. 2), but the amount of damaged seeds introduced to the grain tank decreased.

To determine the influence of the threshing drum on the level of damage, the contents of the tailings auger was directed to a separate container, from which after the determination of the mass of seeds, samples of seeds were taken. Table 1 shows the amount of damaged seeds in this auger (see p. C) with their division into micro- and macrodamage and halves.

It should be mentioned that the high percentage of damage in the tailings auger is also

Table 1. The extent of rape seed damaged (in percent) which appeared in the chosen measurements places

Year	Variety	Canopy (0)				Header (A)				Threshing unit (B)				Tailing auger (C)				Grain tank (D)			
		macro	micro	half	sum	macro	micro	half	sum	macro	micro	half	sum	macro	micro	half	sum	macro	micro	half	sum
1992	Ceres	0.0	0.1	0.1	0.2	0.2	0.8	0.1	1.1	1.8	1.0	2.1	4.9	1.1	2.0	24.6	27.7	2.1	3.4	1.1	6.6
	Bolko	0.5	0.5	0	1.0	0.1	0.5	0.1	0.7	2.0	3.2	2.4	7.6	0.6	1.6	44.2	46.4	1.9	2.6	1.7	6.2
	Mar	0	0.2	0.1	0.3	0.1	0.4	0.1	0.6	1.0	1.1	3.6	5.7	2.2	3.5	11.1	16.8	0.5	1.2	0.8	2.5
	Liporta	0	0.1	0	0.1	0.7	0.2	0	0.9	0.7	1.2	1.8	3.7	0.8	1.9	35.5	38.2	0.9	5.0	1.5	7.4
1993	Ceres	0.2	0	0.1	0.3	0.6	0.2	0	0.8	0.8	1.1	0.7	2.6	1.0	1.2	4.7	6.9	0.8	0.7	0.4	2.6
	Bolko	0.2	0.2	0	0.4	0.3	0.3	0.4	1.0	0.2	0.6	0.8	1.6	0.3	1.1	3.5	4.9	0.2	1.4	0.3	1.9
	Mar	0.3	0.2	0	0.5	0.6	0.1	0	0.7	0	0.1	0.5	0.6	0.3	1.7	3.9	5.9	0.3	0.4	0.3	1.0
	Liporta	0.7	0.6	0	1.3	0.1	0.3	0.1	0.5	0.2	0.6	1.8	2.6	0.7	2.6	10.9	14.2	0.5	2.1	3.0	6.6
	Leo	0.1	0.1	0	0.2	0.4	0.8	0.1	1.8	0	0.5	1.6	2.2	0.5	1.7	34.8	37.0	0.6	1.6	2.1	4.3
1994	Ceres	0.3	0	0.1	0.4	0.5	0.1	0	0.6	0.7	0.9	2.3	3.9	1.7	2.1	15.4	19.2	0.8	1.5	2.0	4.3
	Polo	0.1	0	0	0.1	0.1	0.1	0.1	0.3	1.2	2.1	2.6	5.9	1.2	2.0	23.3	26.5	1.9	2.4	3.1	7.4
	Bolko	0.3	0	0.5	0.8	0.3	0.1	0.6	1.0	0.7	1.4	2.3	4.4	1.1	3.0	26.3	30.4	0.6	2.6	3.3	6.5
	Leo	0.1	0.1	0	0.2	0.3	0	0.2	0.5	0.8	2.0	2.7	5.5	1.3	3.3	20.1	24.7	1.3	2.6	2.5	6.4

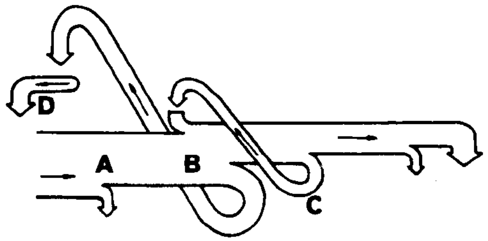

Fig. 2. Scheme of the flow of plant mass in combine-harvester during harvesting. Explanations as in Fig. 1.

a result of the relatively smaller mass transported by this auger (from 9.2 to 26.9 % of the yield). The displacement of this mass of seeds again to the threshing drum causes an additional loading of the threshing unit and grain pan and also further disintegration of seed halves and their blowing outside of the combine.

The analysis of the structure of damage shows that the amount of halves in the grain tank in relation to the amount of halves caused by the operation of the threshing drum decreased. This confirms separative action of the tailings auger. The amount of seeds with microdamage also increased, which shows the destructive action of subassemblies of the combine, and especially of the tailings auger and grain elevator.

To examine the influence of the harvest conditions and the parameters of combine operation on the amount of rape seed damage, three groups of multifactorial analyses of variance were carried out.

The effect of the following factors was analyzed: variety, years, cropping time and working parameters of the combine, such as: slot (8,12 ad 16 mm) and threshing drum speed (600, 800 and 1000 r.p.m.). The rate of seed damage in samples was also compared to the significant areas, from which they were taken (threshing unit and grain tank). In each group of analyses were examined: percentage of microdamaged seeeds, percentage of macrodamaged seeds, percentage of half seeds and percentage of the total damaged seeds. Each experimental combination was represented by the results from 10 randomly taken samples with 100 seeds each. Statistical inference was made at the significance level of $\alpha = 0.05$.

The first group of analyses concerned samples of rape seeds of the Ceres variety coming from 3 successive years of investigations. Drum rotations were a factor which the most significantly effected the rate of rape seed damage. This concerns all the categories of damage. A lower level of damage (in total) was found at 600 r.p.m. An increase of the drum speed caused always an increase of damage, especially high at the increase to 1000 r.p.m. (Fig. 3).

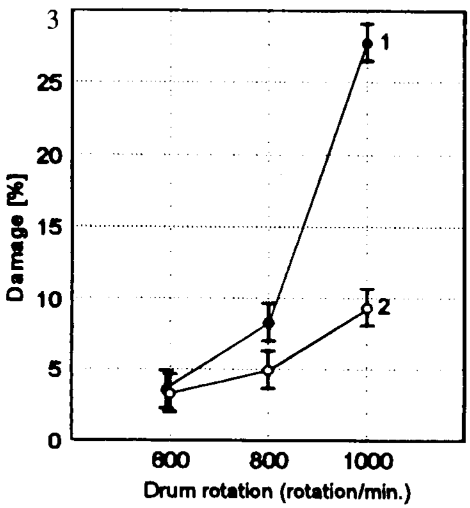

Fig. 3. Effect of drum rotation on seed damage in threshing unit and container.

Of particular interest is the appearance of very high interaction between the drum speed and the areas of sampling. In the case of all categories of damage, a very high level of damage of seeds sampled in the threshing unit at 1000 r.p.m (27.3 %) was unexpectedly found, when at the same speed of the drum only about 9.5 % of damaged seeds were found in the grain tank. At other drum speeds the state of seed damage in the threshing unit and in the grain tank was from 3 % (threshing unit, 600 r.p.m) to 9.5 % (grain tank, 1000 r.p.m). The next significant factor were the years of harvesting. Less damage was found in 1993 (4 %), and the most (12.7 %) in 1994.

Treating all damaged seeds in samples under investigation as 100 %, 28.7 % was with microdamage, 17.0 % with macrodamage, 54.3 % - half seeds. In the case of the threshing unit, at drum speed of 1000 r.p.m, the corresponding percentages were: 17.3 %, 12.9 % and 68.8 %, respectively.

The purpose of the second group of analyses was to compare the effects of combine subassemblies on the occurrence of damage for the chosen varieties of rape. For this purpose the following varieties were taken into consideration: Ceres from 1992, 1993, 1994; Bolko from 1992, 1993, 1994; Mar - from 1992, 1993; Leo - from 1993, 1994; Liporta - from 1992; Libravo from 1993 and Polo from 1994.

Each variety from every year was treated as a separate object. For the analysis, data concerning the optimum harvest time, for 16 mm slot and threshing drum speed of 600 r.p.m were chosen. Samples of seeds from respective objects were significantly differentiated with regard to their state of all categories of damage (Fig. 4).

varieties from 1993 (0.4 to 4.7 %). The attention is drawn to the very strong differentiation of results from particular years for Leo, Ceres and Bolko varieties, which is a result of the effect of weather conditions on the state of seed damage of these varieties.

The year 1992 was an average year, 1993 with a very high rainfall, and 1994 was very dry.

The third group of analyses was carried out to determine the influence of one-stage retarded harvesting on the rate of rape seed damage at different working parameters of combine assemblies. Bolko, Ceres and Mar varieties were taken for the investigation.

Analysing the rate of seed damage of these varieties gathered in 1992 in two terms (optimum and retarded), it was found that for all categories of damage the speed of the threshing drum was the most significant factor which effected the state of rape seeds damage. Similary to the analyses of the first group, in this group less damage in total was noted at 600 r.p.m (4.5 %). An increase of the drum speed always caused a significant increase of damage, especially high at 1000 r.p.m (16.1 %).

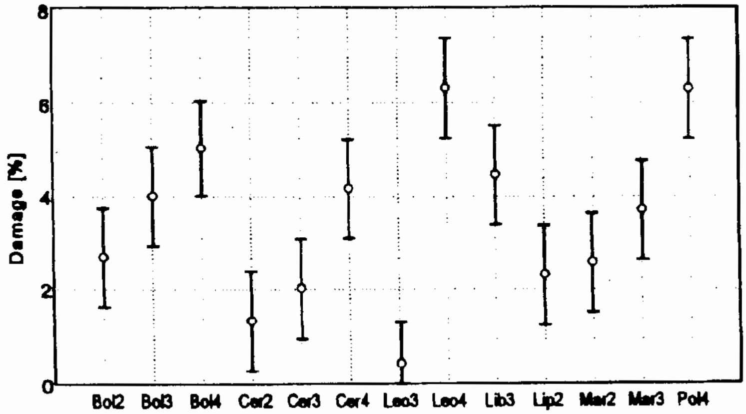

Fig. 4. Rate of seed damage for varieties: Bolko (Bol), Ceres (Cer), Leo (Leo), Libravo (Lib), Liporta (Lip), Mar (Mar), Polo (Pol); 2-1992, 3-1993, 4-1994.

The state of seed damage with varieties from 1992 was relatively low and uniform. For example, an average percentage of seeds with total damage was from 1.5 to 2.6 %. In general the most damage was found for varieties from 1994 - from 4.1 to 6.4 %. The highest, significant dispersion of mean values was found for

Varieties and areas of sampling were the next significant factor. Also significant, but to a lower degree, was the size of the slot. The term of harvesting had no significant effect on the percentage of seeds with any of the categories of damage. For the Bolko variety, retarded term of harvesting appeared to be better, for Mar variety - the optimum term, and for Ceres variety - the state of seed damage in both terms was equal (Fig. 5).

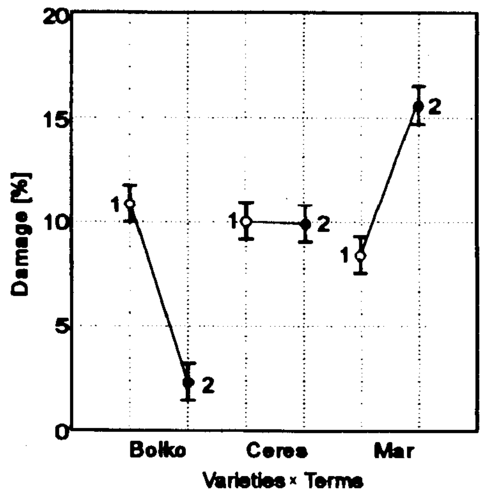

Fig. 5. Effect of harvesting time on the rate of seed damage for varieties: Bolko: 1 - optimum, 2 - retarded; Ceres: 3 - optimum, 4 - retarded; Mar: 5 - opimum, 6 - retarded.

Significantly lower percentage (6.8 %) of seed damage of each category was found with the Bolko variety (Fig. 6). Ceres was with this regard a medium variety (9.9 %) and Mar - the worst (11.9 %).

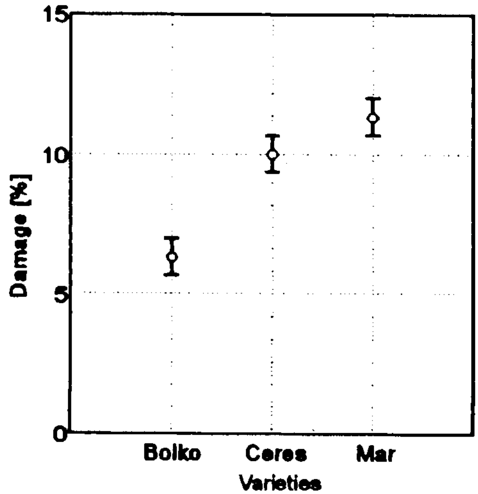

Fig. 6. Average amount of seed damage for varieties: Bolko (bol), Ceres (cer) and Mar (mar).

The average share of half seeds among all categories of damage is equal to 45.5 % (with microdamage - 32 % and with macrodamage - 22.5 %). The size of the slot differentiated in a small degree the state of seed damage (Fig. 7). The most frequently the highest number of damaged seeds was found for the slot of 12 mm (e.g., 11 %). The slot of 8 mm gave intermediate results (9.3 %), but 16 mm - the lowest (8.3 %).

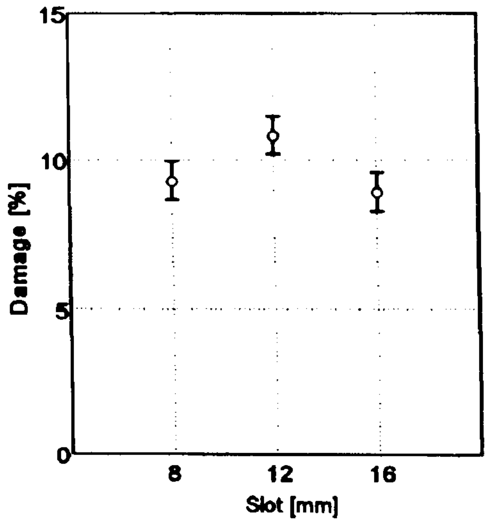

Fig. 7. Threshing slot setting effect on seed damage (8, 12 or 16 mm).

CONCLUSIONS

1. In all rape varieties tested the occurrence of seed damage in the canopy (before mechanical harvesting) was found amounting from 0.1 % for the Liporta and Polo varieties to 1 % for the Bolko variety. The greatest group of damage represents macrodamages (0-0.7 %), and microdamage (0-0.6 %), while half seeds constitute a minority. Only the Bolko variety showed 0.5 % of halves in a dry year.

2. The main source of seed damage in the combine is the threshing unit. An increase of threshing drum speed caused an increase of damage from 1.1 % for the Bolko variety at 600 r.p.m to 47.4 % for Ceres variety at 1000 r.p.m. The damage quantity grew exponentially as the drum speed increased. The reason

of the occurrence of the damage are the flails of the threshing drum, which was confirmed by the increase of damage of dry seeds and especially their division into halves.

3. It was found that during rape harvesting the tailings auger redirects back to the entry of the cleaning unit additional 20 % of seed bulk (up to 66 % of damage) sampled behind the cleaning unit. This additionaly loads the cleaning unit.

4. The greatest resistance to damage was shown for the investigated period (1992-1994) by the Mar variety and the lowest - by the Liporta variety.

5. A marked effect of weather conditions on the magnitude and structure of seed damage for all varieties was found. The greatest damage of seeds took place in the dry year (1994), and the smallest in the wet year (1993).

6. The physical and technological indices under investigation indicate a possibility of maximum reduction of quantitative losses and damage of rape seeds when all the factors determining the physical state of canopy, variety and working parameters of combines are taken into consideration.

7. The analysis of sources of rape seeds damage showed that to reduce these damages to minimum, it is necessary to prepare properly the Bizon grain combine for rape harvesting, taking also into consideration the resistance of individual varieties to the impact of mechanical forces.

It is worth to stress the fact that in the group of the damage under analysis, micro-damage, not visible with the naked eye, makes the highest percentage. However, it becomes dangerous during rape seeds storage when microbes find easy access to the interior of the seeds.

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ŹRÓDŁA I PRZYCZYNY POWSTAWANIA USZKODZEŃ NASION RZEPAKU PODCZAS ZBIORU KOMBAJNEM

W kombajnie zbożowym Bizon-Super, wytypowano miejsca, z których pobierano próbki w celu ustalenia źródeł powstawania uszkodzeń nasion w taki sposób, aby uzyskane rezultaty jednoznacznie określały wpływ poszczególnych zespołów i ich parametrów na stopień uszkodzenia nasion rzepaku. Ocenie uszkodzeń poddawano nasiona stanowiące reprezentatywną próbkę całej partii nasion pobranych w poszczególnych punktach pomiarowych, w sposób losowy, z podziałem na makro- i mikrouszkodzenia oraz połówki. Badania prowadzono w okresie trzech kolejnych lat na siedmiu odmianach rzepaku ozimego. W pracy przedstawiono rozkład uszkodzeń występujących na wybranych zespołach kombajnu, przy różnych parametrach ich pracy i w dwóch terminach zbioru.

S ł o w a k l u c z o w e: rzepak, zbiór kombajnowy, uszkodzenia nasion.