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ABRASION SUSCEPTIBILITY OF TRITICALE GRAIN AS A FUNCTION OF GRAIN MOISTURE CONTENT AND BASE KIND

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A b s t r a c t. A measuring stand for triticale grain abrasion testing has been designed and made. Tests have been carried out with the use of 'Lasko' variety grain. Test results have been statistically elaborated and presented in the form of graphs expressing percentage values of grain cover and endosperm damage in respect of moisture content of grains and base plate used for the abrasive operation.

INTRODUCTION

Constant growth of the vegetable production process mechanization causes an increase of the grain damage grade. Grain production mechanization program assumptions show that it will not be possible to avoid such damage [3]. However, it will be necessary to limit them because they have a negative influence onto biological values of grain as a sowing material and also make grain technological properties worse. Damage of a fruit-seed cover can be the cause of grain heating and intensive occurrence of deseases [2]. Knowledge concerning the variability of grain physical properties and competence in the use of obtained information for cultivation of new varieties having adventageous properties and for ensurance of the best results of all processes related to the production cycle [7] is one of systems enabling to avoid great grain losses. Therefore it is a natural consequence that scientists are interested in research on plant properties which would be able to determine objectively the physical state of plants and to describe it in a way sufficient for production process mechanization necessities.

Grain damage may occur as fruit-seed cover microdamage and as inner structure changes even without grain shape changes, e.g. in the form of bud seed tissue separations.

All known grain damage determination methods may be divided into two following groups: direct methods which determine damage occurring on seeds and indirect methods which enable to find damage on the base of intermediate occurrences correlative to existing damage in any way [6].

The triticale is a plant cultivated for a short time and therefore it has not yet been submitted to accurate tests. Physical properties of other grain plants were determined on the basis of many various tests which had been specified in literature [1,4,5,8].

Tests carried out by us were aimed at determining the Lasko variety triticale grain damage occurring as an effect of abrasion in relation to grain moisture content at selected abrasive materials (conveyor belt rubber and steel plate).

METHODS

The grain material provided for testing (triticale of Lasko variety) has been divided into three fractions by sieving the grain through sieves of the following mesh sizes: 3.5 mm, 2.5 mm and 2.0 mm. Grain remaining on the sieve of 2.5 mm mesh has been tested after moistening to requested moisture content levels.

Fruit-seed cover abrasibility tests have been carried out by means of a device of our own construction shown in Fig. 1.

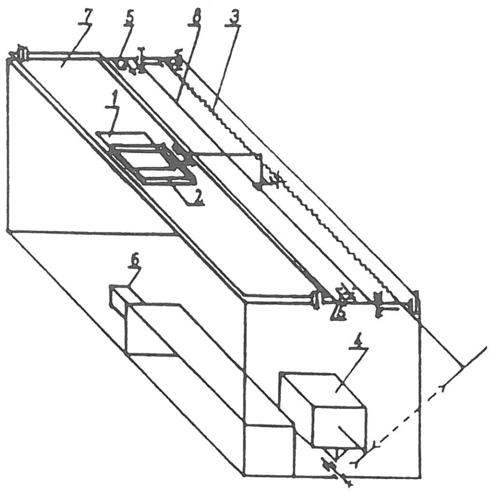

Fig. 1. Scheme of a stand for testing a grain damage during an abrasion process. 1-organic glass board, 2-frame, 3-feed shaft, 4-electric motor, 5-limit switches, 6-electric relay, 7-race of conveyor rubber and steel sheet, 8-guides.

A grain was fastened in a hole drilled in an organic glass board, item 1, by means of an adhesive mixture. This board was inserted into a movable frame, item 2, shifted by means of a feed shaft, item 3, drieven by an electric motor, item 4. The measuring stand was fitted with exchangeable races, item 7.

Tests were carried out on a base made of conveyor belt rubber and steel sheets. Grains were moved along the race at a speed equal to v=0.055 m/s. The mass loading the sample and the lenght of the abrasion travel have been selected empirically. There has been applied a loading force equal to F=4.973 N and a friction travel equal to l=2 m. The abrasion test has been carried out on a caryopsis back side. Tests have been carried out for 20 various moisture content grades of grain within the range from W=8 % to W=31.2 % at 20 repetitions for each moisture level. Then the grains were immersed in a solution of iodine in potassium iodide at 0.5 % concentration for 2 min. After washing and drying the grains were immersed in 0.1 % eosine solution for 3 min and washed and dried again. Such treatment was carried out in order to obtain a picture of abrasive damage owing to different colours of damaged places, i.e., a dark colour of starch caused by Lugol fluid at damaged endosperm points and a pink colour caused by eosine at damage points of seed-vessel outside layers. In order to attain an accurate determination of sizes of mechanical damage there have been made photos of grains on a colour positive film. The pictures obtained were magnified by means of a microfilm enlarger and grains as well as damaged areas have been contoured. Areas of these contoured surfaces have been computed with the help of a planimeter. Then the whole grain area, the damaged endosperm area and the non-damaged area were estimated (Fig. 2).

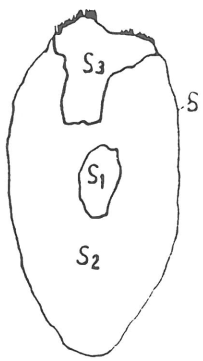

Fig. 2. Exemplifying drawing of triticale grain surface damages. s-total area of a caryopsis, s_1-damaged endosperm area, s_2-damaged seed-vessel outside layer area, s_3-non-damaged surface area.

The area S_2 of the damaged seed-vessel outside layer has been calculated from the following equation:

$$S_2 = S - S_1 - S_3 \qquad (1)$$

where S - caryopsis total area, S_1 - damaged endosperm area, S_2 - damaged seed-vessel outside layer area, S_3 - non-damaged area.

Grain damage ratios were determined as a damaged endosperm area percentage and a damaged seed-vessel outside layer percentage. Calculations were carried out for all moisture contents and both kinds of bases.

The damaged endosperm area percentage is calculated from the following formula:

$$S_1 = \frac{\sum_{i\varepsilon(1;20)}^{i} S_1}{\sum_{i\varepsilon(1;20)}^{i} S} \cdot 100\,. \qquad (2)$$

The total damaged area percentage, i.e., the sum of damaged endosperm area and damaged seed-vessel outside layer percentage is calculated from the following formula:

$$S_{1+2} = \frac{\sum_{i\varepsilon(1;20)}^{i} S_1 + \sum_{i\varepsilon(1;20)}^{i} S_2}{\sum_{i\varepsilon(1;20)}^{i} S} \cdot 100\,. \qquad (3)$$

Non-damaged surface percentage S_3 was calculated from the following formula:

$$S_3 = \frac{\sum_{i\varepsilon(1;20)}^{i} S_3}{\sum_{i\varepsilon(1;20)}^{i} S} \cdot 100\,. \qquad (4)$$

In order to show mutual relations of relevant results the equations for the following functions were calculated: $S_1=f(W)$, $S_{1+2}= f(W)$, $S_3=f(W)$. The graphs of these relations were also prepared.

RESULTS

An analysis of the damaged endosperm area shows that the damaged surface percentage increases due to a moisture content growth. This relationship for rubber and steel bases may be determined by means of the following general equation: $y=aW^b$. The lowest value of the endosperm area which is subjected to damage, S_1=0.23 % has been obtained at a moisture content W=12 % for the conveyor rubber base. This value for a steel base is somewhat higher and is equal to S_1=1.62 %. The highest value of the endosperm area which is subjected to damage, S_1=73.09 %, has been obtained on a rubber base at moisture content W=32 % (Fig. 3). Test results show that up to a moisture content value of W=21 % there will be lower value of an area on which the endosperm is

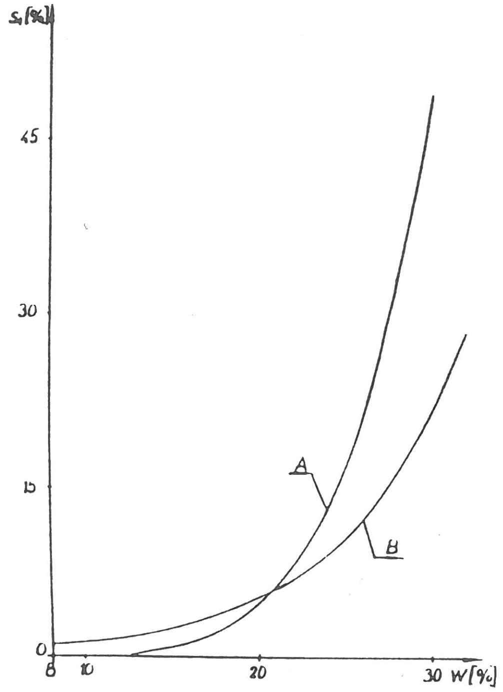

Fig. 3. Damaged endosperm area percentage (S_1) related to moisture content (W). A-at abrasion on the ruber base, B-at abrasion on the steel base.

damaged for a conveyor rubber base and above the moisture content W=21 % - for a steel base.

The area value at which the endosperm and the seed-vessel outside layer have been damaged in the function of the grain moisture content is increasing in a linear manner for both kinds of bases applied. The greatest damage S_{1+2}=100 % has been observed at the rubber base because already from the moisture content of W=27.2 % grains were completely destroyed. The complete destruction of grain at the steel sheet base has been observed at the highest moisture content value of W=31.3 % only. Analysing the damaging process according to moisture content as shown in Fig. 4, it is possible to ascertain that a smaller value of the damaged area percentage at low moisture content values is observed at the rubber base and not at the steel base. This difference becomes lower with increasing humidity. The maximum number of damage, i.e., S_{1+2}=100 % at both tested bases has

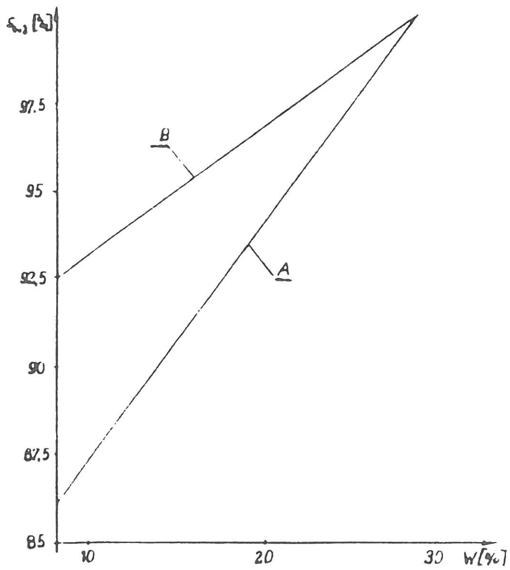

Fig. 4. Damaged endosperm and seed-vessel outside layer area percentage (S_{1+2}) related to moisture content (W). A-for ruber base, B-for steel base.

been observed for almost identical moisture contents W=28.8 %.

The investigations carried out have shown that the non-damaged surface percentage is a linear function as in Fig. 5.

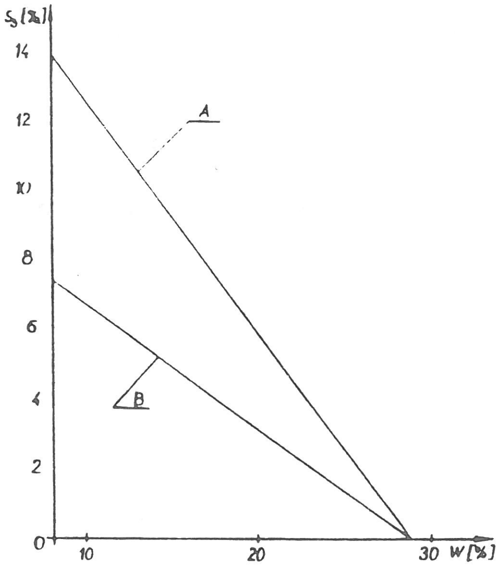

Fig. 5. Percentage of non-damaged area (S_3) during abrasion related to moisture content (W), A-rubber base, B-steel base.

CONCLUSIONS

1. The range of endosperm damage on the conveyor rubber is a growing exponential function and the damage percentage values are within S_1=0.23 % and S_1=73.08 %, at moisture content values from W=12 % to W=32 %, respectively. For the steel base these damage percentage values are from S_1=1.63 % to S_1=28.98 %, respectively.

2. Endosperm and seed-vessel outside laye damage on a rubber base and a steel base are changing due to the moisture level according to growing linear functions. Within moisture content range from W=12 % to W=28.8 % at the rubber base, the percentage of damage is within values: S_{1+2}=88.78 % to S_{1+2}=100.00 %, and at the steel sheet base

from S_{1+2}=93.97 % to S_{1+2}=100.00 %, respectively.

3. A lower number of grain damage is caused by the conveyor rubber base. The steel sheet has proved to be a less damaging base than the rubber base for grain with a moisture content value above W=21 %, but only in the case of endosperm damage.

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