

Evaluation of suitability for mechanized harvesting of sesame genotypes, introduced in Portugal

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Abstract

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A laboratory evaluation of the susceptibility for mechanized harvesting of seeds for eleven sesame genotypes introduced in Portugal has been conducted by two Bulgarian methods. The first one identifies three indices, each of which is indicative for the self-squandering of seeds or for their retention in the capsules due to the narrowing of capsules or for the force of connection between seeds and the placenta. The obtained results show that Bulgarian varieties Aida, Valya and Nevena retain the seeds in capsules due to placenta attachment therefore they are the most suitable for inertial threshing. The remaining genotypes retain their seeds because of narrowing of capsules with decreasing of moisture content. For this reason they are suitable for conventional threshing at moisture content of seeds below 7%, but with some probability of losses due to incomplete releasing of seeds.

Keywords: sesame; mechanized harvesting; assessment; methods; harvesting

Introduction

In recent years, there has been interest in mechanized cultivation and harvesting of sesame in Portugal as an alternative to crops that do not tolerate the rise in temperatures due to global warming. In the period 2010-2017 at the Beja University, sesame lines of different origins were introduced with the task of determining their suitability for mechanized growing and harvesting in the conditions of Portugal.

The mechanized cultivation of sesame is done by conventional mechanization, but mechanized harvesting of the crop without significant losses is an unresolved problem worldwide. The effectiveness of mechanized harvesting of sesame

is determined mainly by the variety and more precisely by its ability to retain the seeds in capsules at maturation and to release them into the threshing mechanism. Langham (1998) proposed the following values and provided photos illustrating shatter resistance:

- SUSHA (SUS) = super shattering – retains less than 10% of seed;
- SHA = shattering – retains 10-50%;
- NOSHA (NSH) = non-shattering – retains 50-70%;
- DC = direct combine – retains 70-100%;
- ID = Indehiscence allele present – retains all seed;
- IDO = Indehiscence allele present but modifiers open the tip, but retains most of the seed;
- GS = Seamless allele present – retains all seed;

- GSO = Seamless allele present but modifiers open the tip, but retains most of the seed.

An objectively independent method has been developed for assessment the susceptibility of sesame genotypes for mechanized harvesting of the seed in laboratory conditions (Ishpekov & Stamatov, 2015). The assessment requires 100 capsules of each variety - one week before opening their tops. Such amount of capsules is necessary for assessment the genotypes at three values for moisture content of the seeds. The method defines three indexes that are determined by a simple portable pendulum apparatus. The indices characterize the retention and release of the seeds by the capsules as a result of the mechanical impacts that are typical for the grain harvesters.

The first index i_1 is a criterion for self-squandering of seeds. Genotypes with a high i_1 value are unsuitable for mechanized harvesting because they scatter their seeds as a result of mild mechanical impacts such as shaking by the wind or by the bat reel of combine harvesters (Ishpekov et al., 2017 b).

The second i_2 index is a criterion for retaining seeds by the capsules due to their shape. The genotypes with high values of i_2 require shredding of the capsules for releasing the seeds, which is carried out by threshers or shredders.

The third index i_3 assesses the susceptibility of genotypes to release the seeds at application of an inertial impulse, which is called inertial threshing (Ishpekov et al., 2016). Based on this principle has been developed and patented inertial detacher, that separates from capsules over 95% of seed which moisture content is from 12.2 to 13.3% (Ishpekov et al., 2017 a). It releases the seeds without deforming the stems and capsules and for this reason the total power consumed by the inertial detacher is 4.81 times smaller than by the conventional thresher with the same productivity (Zaykov et al., 2017).

The high values of the indices i_2 and i_3 and the low value of i_1 is evidence to the ability of the tested variety to retain the seeds in the capsules until their entry into the harvesting machine as well as for the susceptibility to their threshing.

Furthermore, the method allows studying the shock shattering indices of sesame capsules that remain closed at maturation (Ishpekov et al., 2008).

It has been determined that the appropriate shock impulse for the releasing seeds from closed sesame capsules with a moisture content of 8.2% is in the range of 45 , 0.65 kg.m/s at width of the striker more than 5 mm. The single impact causes release up to 69% of the seed from non-shattering capsules of variety Irina and up to 87% of variety Sadovo 3959 without causing damage to the seeds.

For mechanized harvesting of these varieties in Bulgaria

has been developed a thresher that first shredded and then threshed the sesame capsules (Kollev et al., 2012). This machine can also work with whole dried sesame stems. It threshes up to 91% of the seeds with moisture content of 5.9% while maintaining their germination.

This method is applied in the selection of Bulgarian sesame varieties assigned for mechanized harvesting (Stamatov et al., 2016; 2017).

The purpose of this study is to estimate the suitability for mechanized harvesting of sesame genotypes that are introduced in Portugal.

Keywords: sesame; mechanized harvesting; assessment; harvesting methods

Material and Methods

Plant material

There have been tested the capsules of eleven sesame varieties, introduced in Portugal. Three of them - Aida, Valia and Nevena have Bulgarian origin (Fig. 1 and Fig. 2). The other varieties are introduced from Portugal. All varieties are assigned for mechanized harvesting with non-shattering capsules of DC type. Only the genotype 504 has closed capsules of ID type at full maturity. All genotypes are characterized with placenta attachment of seeds and other anatomical features of the capsules that prevent seed spillage at maturation.

Bulgarian varieties have length of the capsules which varies from 24 to 28 mm and their weight in a completely dry condition is from 1.2 to 1.5 g. The seeds in one capsule have a mass of 0.74 to 0.95 g.

Other genotypes have length of the capsules from 39 to 45 mm. The weight of a dry capsule is from 1.3 to 2.4 g. The seed mass from one capsule ranges from 0.77 to 1.9 g.



Fig. 1. The tested genotypes

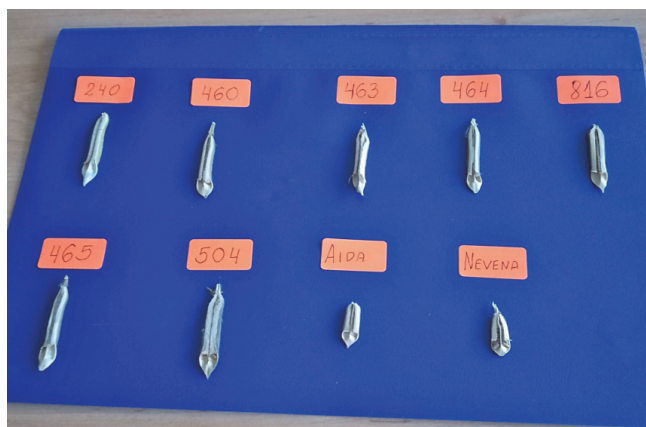


Fig. 2. Membrane and shape of the capsules of the examined genotypes



Fig. 3. Pendulum apparatus for testing the susceptibility of sesame capsules for mechanized releasing of seeds: a) at determining indices; b) at determining the proportion of released seeds as a result of shock impulse

Method

The study was conducted on the subjectively independent method for assessing the susceptibility of the sesame genotypes to mechanized harvesting (Ishpekov & Stamatov, 2015). The three indices of capsules of the presented genotypes were determined experimentally at three seed humidities in technological maturity. For capsules with a high value of index i_2 have been applied the method for determining the proportion of released seeds as a result of shock impulse (Ishpekov et al., 2008). The application of the two methods is carried out with a simple pendulum apparatus (Fig. 3). In the first case, tested capsules are glued on the lower plane of the pendulum and in the second – at the forehead of the striker. All measurements were performed with three replicates. The moisture content of the seeds was determined by the weight method just after each measurement.

Results and Discussion

The three indexes were determined for all genotypes at three values of moisture content in the seeds - above 14%, above 10% and below 10%, which are typical of technological maturity.

The variation of index i_1 depending on moisture content of seeds of the tested genotypes is shown in Fig. 4 and Fig. 5. The type of curves divides the tested genotypes into several groups depending on the change in susceptibility to seed shattering due to mild mechanical impacts. For the group of Aida, 460, 463 and 464 this index has maximum values at 10-12% moisture content of seeds. At the mentioned moisture, the top of the capsules breaks out, as a result of which the placenta lying on the top dries out of its contact with the seeds. Genotypes Valia, Nevena and 504 form a second group for which the index i_1 has a minimum value at the same moisture, because the tip of their capsules is not yet open. The genotype 240 decreases linearly the value of index i_1 with decreasing of seed moisture. This genotype retains the seeds due to the contraction of the capsules, which is proportional to the decrease of seed moisture. The value of index i_1 for the genotype 465 is unaffected by the change in seed moisture. The i_1 values for the genotype 816 are many times higher and therefore are presented on a separate graph (Fig. 5). It rises sharply at moisture below 10% and reaches 3.4, which indicates a high susceptibility to self-shattering of the seeds. Apparently, this genotype is not suitable for mechanized harvesting.

The plots of index i_2 depending on moisture content of seeds for the tested genotypes are presented in Fig. 6. It is seen that the genotype 816 has the lowest ability to retain the seeds in the capsules at moisture less than 12%. The

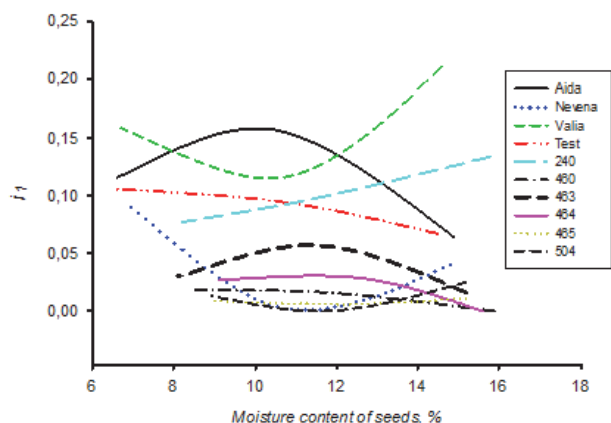


Fig. 4. Index i_1 depending on the moisture content of seed for tested genotypes

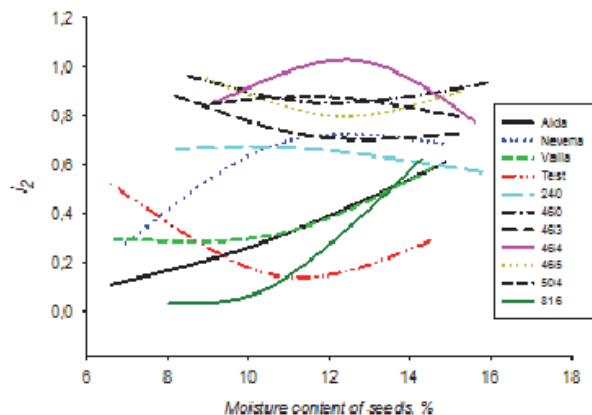


Fig. 6. Index i_2 depending on the moisture content of seed for tested genotypes

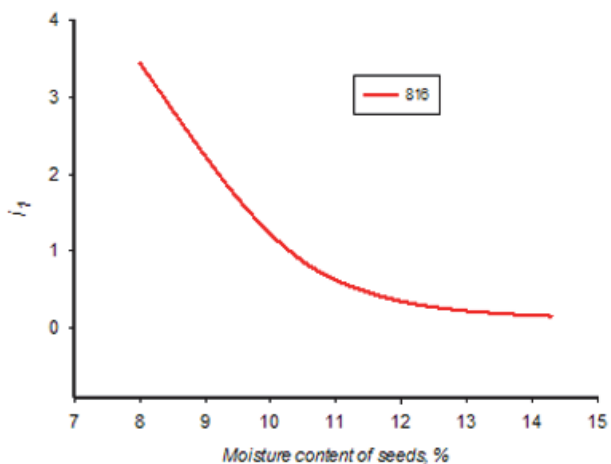


Fig. 5. Index i_4 depending on the moisture content of seed for genotype 816

highest values of this index have the genotypes 464, 460, 504, 463, 465 and 240. Of great importance is the fact that they maintain the high values of i_2 even at decreasing of seed moisture below 8%, which is due to the narrowing of the capsules at maturity. These genotypes are best suited for mechanized harvesting by disintegrating the capsules. Bulgarian varieties Aida, Valya and Nevena have lower values of the i_2 index, especially when the seed moisture decreases. They retain the seeds in the capsules by the placenta, but at a humidity of less than 10% it dries, becomes brittle and releases them. These varieties also allow mechanized harvesting, but at seed moisture of 10-12%. If conventional threshing at this moisture is applied, that can be expected mechanical damages to harvested seeds and decreasing of their germination.

The i_3 index is indicative for the strength of the relationship between the seeds and the placenta (Fig. 7) and for the possibility of inertial threshing. (Ishpekov et al, 2016). At seed humidity of 10-12%, the highest value of i_3 has the genotype Test, and the lowest value - 816, but the change in moisture greatly reduces the index. It grows steadily with a decrease in moisture for Bulgarian varieties, which proves that they are best suited for inertial threshing. The values of i_3 for other genotypes indicate that they have a weaker relationship between the seeds and the placenta.

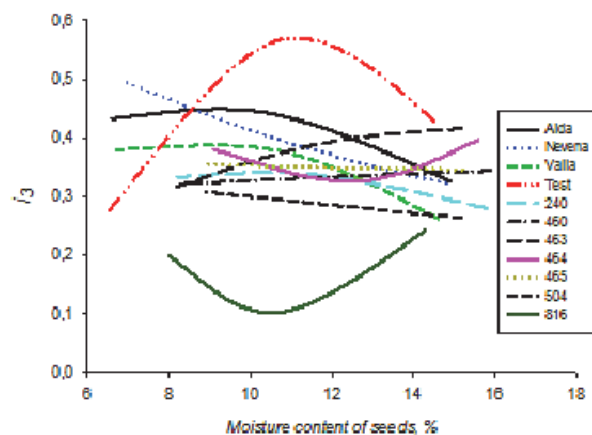


Fig. 7. Index i_3 depending on the moisture content of seed for tested genotypes

The study of the seed released depending with the given shock impulse is imposed on genotypes with high index i_2 and low i_3 , because they release their seeds only after break-

ing the capsules. Genotypes 240, 460, 463, 464, 465 and 504 were subjected to this test at seed moisture of 6.6 - 7.2%. The results show that the highest percentage of seeds is released by the shock impulse in the range of 0.35-0.40 kg.m/s (Fig. 8).

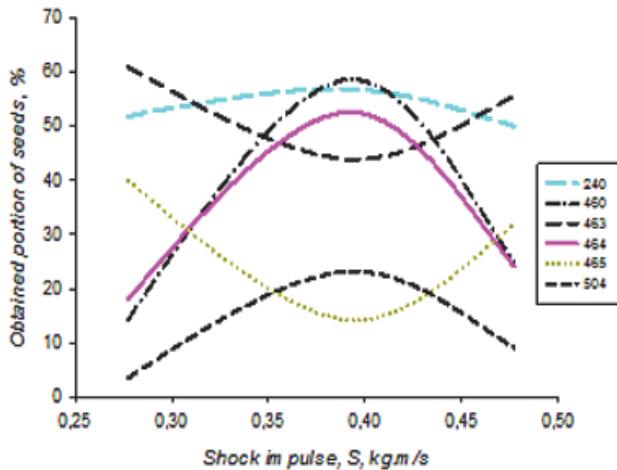


Fig. 8. Proportion of released seeds depending on given shock impulse on the capsules



Fig. 9. A capsule damaged by a shock impulse

On shock impulse over 0.45 kg.m/s, the proportion of released seeds decreases, because they left in the capsules and are severely damaged (Fig. 9 and Fig.10). These genotypes are characterized with a tightly adhering membrane and with narrowing the walls of the capsules at drying (Fig. 2). On the one hand, this prevents the release of the seeds due to shaking of the plants, but on the other hand it causes threshing losses at the studied moisture.

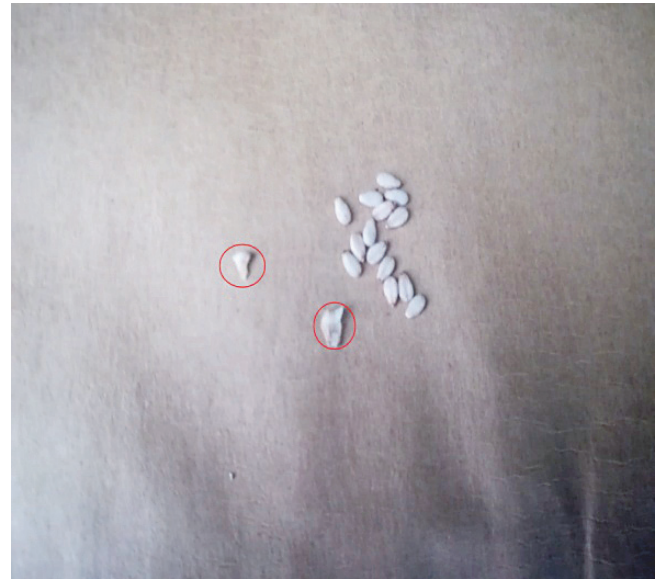


Fig. 10. Damaged seeds

The obtained results show not only the suitability for mechanized harvesting of tested sesame genotypes. They are also indicative for different directions of selection which are applied to obtain varieties which are suitable for mechanized harvesting of seeds. In Bulgaria the selection process is directed to stringing of the placenta (high index i_3), but in other countries such as the United States and Australia there is significant research to narrowing the capsules at maturity (high index i_2). The difference between the two approaches is caused by the different climatic conditions at which harvesting takes place. In Bulgaria the moisture content of the seed during harvest does not fall below 9% in the field. At this moisture, the capsules are difficult to crush, but release their seeds by inertial threshing. In other countries, seed moisture drops to 6% under field conditions, making capsules susceptible to conventional threshing (Langham, 2004).

Conclusions

Of the eleven genotypes that are introduced in Portugal, ten have retained their seeds in the capsules at maturity. Only

the genotype 816 is not suitable for mechanized harvest due to self-squandering of the seeds. The three Bulgarian varieties Aida, Valia and Nevena retain the seeds in capsules due to the attached placenta and therefore are most suitable for inertial threshing. The remaining genotypes retain their seeds due to the narrowing of the capsules with a decrease in moisture and are therefore suitable for harvesting by conventional threshing at moisture content of seeds below 7%, but with some possibility of losses from incomplete threshing. Both ways of retaining the seeds in the capsules are indicative for the directions of selection of sesame varieties, which are suitable for mechanical harvesting in Bulgaria and other countries

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