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METHOD FOR ASSESSMENT THE SUSCEPTIBILITY OF SESAME GENOTYPES FOR MECHANIZED HARVESTING OF THE SEED

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Abstract

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It is given proof of a method for assessing the susceptibility for mechanical harvesting of sesame genotypes. The method allows determination of appropriate way for mechanical harvesting of the seed, which can be with or without breaking of the capsules. The method has been applied to assess the susceptibility of six sesame genotypes, selected in IPGR- Sadovo, Bulgaria. The results are well concerted with those, obtained for the same genotypes at harvesting by grain harvester.

Key words: sesame, harvesting, mechanization, selection

Introduction

In recent years many non-squandering sesame genotypes have been selected and thus created conditions for mechanized harvesting (Uzun et al., 2003). Depending on condition of the capsules during maturation there are two groups. The first group genotypes have fully enclosed capsules (Langham, 2001). Genotypes of the second group have capsules with open peak, but keep the seeds connected to the placenta (Georgiev et al., 2014).

Harvesting of sesame is done in two ways. The first one is by breaking the capsules, which occurs in threshers. The conditioned moisture of seeds should be below 8%, otherwise they get damaged mechanically. This way is applicable to regions with hot and dry climate or at two-step harvesting with intermediate drying of the plants.

The second way for seed harvesting is without breaking up the capsules. To the stems are given sharply changing mechanical impacts, which create an inertial force that affects every seed. It causes exemption of the seeds without breaking up the capsules. The harvested seeds are not mechanically damaged even if their moisture content is 16%. Actually, the second way is inertial and is applicable to regions with humid climate during the harvesting of sesame (Ishpekov, 2015a).

Despite created genotypes, developed technology and machines, the mechanized harvesting of sesame is accompanied by big losses (Ishpekov, 2014).

Future research on mechanized harvesting of sesame seeds is restrained by the lack of objective criteria for assessing the ability of the capsules to hold the seeds in. Also, there is no reciprocal criteria for assessment the susceptibility of the capsules to release the seeds. Neither a certain criteria is known in order to determine the appropriate way for mechanized harvesting of sesame - with or without breaking the capsules.

The absence of those criteria hinders and delays the selection of sesame genotypes, which are intended for mechanical harvesting. It reduces the possibility of comparing the genotypes prior to their introduction. It is difficult to assess the effectiveness of the mechanical impacts for harvesting the seeds of sesame.

The target is developing a method for objectively assessing the susceptibility to mechanical harvesting of sesame seeds as well as to choosing out the method for it conducting.

Method and Materials

Approach

It consists of developing a method for assessing the susceptibility to mechanical harvesting of sesame seeds and its application for several sesame genotypes respect to show its potentiality.

The mentioned susceptibility depends on the following parameters:

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- The proportion of seeds that have been exempted from the capsules at maturation- m_{c1}, [%]. It includes the seeds that are released at maturation by:
  - ✓ the cracking the top of the capsules;
  - ✓ the longitudinal splitting the capsules;
  - ✓ the smooth rotation of the capsules with the top down.
- The proportion of the seeds remaining in the capsules after the inertial impact - m_{c2}, [%];
- The proportion of the seeds, leaving the capsules because of the inertial effect- m_{c3}, [%].
- The obtaining of the portions m_{c2} and m_{c3} are described at Ishpekov et al. (2015b) in detail. In this study the applied mechanical impact for releasing the seeds from the capsules is inertial. Therefore:
- The portion of m_{c1} determines the susceptibility to squandering of the seeds for each genotype at shaking the plants by the wind or by low-speed mechanical impact of the harvesting machines. It is possible to harvest these seeds mechanical if the capsules have not been spitted and the plants have been fed into the machine without significant tilting.
- The proportion of m_{c2} is indicative of the retention of the seeds in the capsule, caused by its type and shape. Important is the presence of the narrowings, as well as size of opening on the peak and longitudinal split of the capsules during maturation period.
- The share of m_{c3} is indicative for the strength the connection between seeds and placenta. It is also informative for susceptibility of the capsules for releasing of seeds due to the inertial impact.

Apparently, the parameters m_{c1}, m_{c2} and m_{c3} are influenced differently by the susceptibility to mechanical harvesting of the genotypes. Therefore, for the quantitative assessment of this susceptibility we have introduced the following complex indices:

$$i_1 = \frac{m_{c1}}{m_{c2} + m_{c3}}, \quad (1)$$

$$i_2 = \frac{m_{c2}}{m_{c1} + m_{c3}}, \quad (2)$$

$$i_3 = \frac{m_{c3}}{m_{c1} + m_{c2}}, \quad (3)$$

From mathematical point of view, all indices are changing in the range from 0 to 100, but their real values are in the range 0.05 ÷ 20. In the value 0.05 the numerator is approximately 5%, and the denominator is 95% and in the value 19 - their ratio is the opposite. If the value is 1 then the numerator and denominator are equal.

Obviously, the first index i_1 is the criterion for dispersal of seeds. The second index i_2 is a criterion for the retention of the seeds in the capsule, due to the peculiarities of its shape during harvesting. The third index i_3 is a criterion for the strength of the relationship between the seeds and placenta.

Therefore, the genotype with high value of the index i_1 is unsuitable to mechanical harvesting due to scattering of seeds. This one with high value of the index i_2 is suitable for harvesting through threshing. The high value of the index i_3 is indicative for suitability for harvesting the seeds without breaking up of the capsules.

When the value of the first index is close to 0.05, and the values of i_2 or i_3 - to 20 it can be considered that the tested genotype is perfectly amenable to mechanical harvesting. The higher value of i_2 or i_3 showed which way is more appropriate for harvesting - with or without breaking the capsules.

Determination of indices for susceptibility to mechanical harvesting of sesame genotypes

The index values are dependent on the genotype, degree of maturity, moisture of seeds and capsules, and applied inertial impact as well. Its parameters has been given and measured through a stand in laboratory conditions.It is composed of a pendulum apparatus and an electronic system for measuring and recording the angle of rotation of the pendulum (Ishpekov, 2015c). It is given an inertial force $F_{in} = 5\ 10^{-4}N$, which is directed towards the top of the capsule and is parallel to its length.

The seeds that have been released from the capsules due to inertial force are scattered everywhere and it is impossible to collect them. Therefore, their ammount has been determined in an indirect way, by weighting of:

- m_0 - the mass of tested capsules before the experiment, [g];
- m_{c1} - the total mass of the seeds, that fall as a result of slow rotating of the capsules with the top down and those that have been exempted from the capsules at their drying and maturation, [g];
- $m_2 = m_0 - m_{c1} + m_{gl}$ - the total mass of the tested capsules and mass of the glue for their adhesive bonding to the pendulum, [g];
- m_{gl}- the mass of the glue for pasting the capsules on the pendulum, [g];
- m_3 - the mass of capsules after the inertial impact, [g];
- m_{c2} - the mass of the seeds remaining in the capsules after the inertial impact, [g].

The mass of the glue has been determined as difference of the readings of the precision scales before and after its deposition on tested capsules. This is acceptable because the mass of the used glue Loctide-406 does not change significantly

during hardening. The mass m_{c2} has been determined after manually breaking up of the capsules and removing the remaining seeds. The mass of the seeds, leaving the capsules because of the inertial impact was calculated through:

$$m_{c3} = m_2 - m_3 , [g] \quad (4)$$

The total mass of seeds has been determined as follows

$$m_c = m_{c1} + m_{c2} + m_{c3} , [g] \quad (5)$$

After that the percentages of m_{c1}, m_{c2} and m_{c3} toward m_c has been calculated for the tested genotypes. Their values have been used for calculating indices i_1, i_2 and i_3, (1), (2), (3).

Experimental materials

Six sesame genotypes selected in IPGR - Sadovo, Bulgaria have been examined. Their names are Aida, Nevena, Valya, Milena, 4090 and 4079. During maturation, they open only the top of the capsules and the placenta retained part of the seed up to full maturity. 20 plants have been cut from each genotype while they were in technological maturity and their boxes were completely closed. In this state the plants have been cut off and packed in a paper-bag by fours. These bags have been prepared for all experiments. The bags have been left in the laboratory until the opening the tops of capsules, which is a sign for starting the seed harvesting.

Measurements have been conducted at three stages of the moisture of the seeds. The first is when only a few capsules have openedfro all plants; the second is at the opening of all capsules and the third - at full maturity of seeds. The seeds and capsules moisture contenthas been measured daily by electronic moisture meter of the company Sigma Tech, which has been calibrated by the manufacturer for sesame. Also, number of days to reach the mentioned stages of moisture has been counted, which is necessary for determining the optimal duration for the mechanized harvesting. The masses m_{c1}, m_{c2} and m_{c3} have been measured with an electronic scale. It is recommended to test more than 30 sesame capsules in order to satisfy statistical requirements for representative sample.

Results and Discussion

The resulting indices for tested sesame genotypes are presented in Table 1. The highest values for i_1 have the genotype Valya, followed by 4079 and Nevena when the moisture content of the seed has been 14.6 ÷ 15.1%. When moisture has been decreased to 9.9 ÷ 11.5%, 4090 has joined these genotypes. They are unsuitable for mechanical harvesting, because dissipate the majority of the seeds due to longitudinal cleavage of the capsules.

It has been expected that lowering the moisture of the seeds decreases the values of i_2. This is truth for the genotypes Aida, Valya, Milena and 4090, because the capsules have released the seed due to a reduction of its volume on drying. For genotypes Nevena and 4079 has been observed another phenomenon. Lowering the moisture causes uneven shrinkage of the capsules. It leads to retention of seeds in some zones, while their longitudinal split occurs.

It has been expected that the reduction of the moisture content lowers the values of i_3, due to weakening of the relationship between the seeds and placenta. In the genotypes Aida and 4079 have been observed the opposite phenomenon, but a short time. It is explained by the fact, that in the process of drying the placenta becomes rubbery and after that - brittle. At that condition the seeds are released by light mechanical impacts.

It is obvious that the three indexes should be determined in three levels of the moisture of the seeds and the capsules. Tracing the change of the indexes allows assessing the susceptibility to mechanical harvesting throughout the period of maturation of different genotypes.

Experimental results have shown that the genotype Aida is the most suitable for mechanized harvesting, because it has the lowest index i_1. The reason is that this genotype scatters the least seeds during maturation. At the high humidity it keeps most of the seeds in the capsules, but the placenta releases them at application of inertial impacts. In case the moisture is 14.6 ÷ 15.1% Aida is most susceptible to harvest without breaking the capsules. When the humidity decreases to 9.9 ÷ 11.5%, Aida becomes the most suitable for harvesting by threshing. Its indices show that the placenta has retained seeds in lowering humidity, because then it becomes more resistant to tearing. Of course this conclusion is valid for the range of change the moisture of seeds in present study.

The data in Table 1 show that the indices of studied genotypes differ significantly from those of the genotype, which is ideally amenable for mechanized harvesting. This means that we need more targeted selection work to improve sesame genotypes.

The losses of a plot grain harvester Wintersteiger at harvesting the sesame genotypes Aida, Nevena and Valya are presented in Table 2. It is evident that the findings made by the index values are well concerted with the experimental data for the losses for all genotypes. This means that the developed method for determining susceptibility for mechanized harvesting of sesame genotypes is objective.

The developed method can be used in the following cases:

- To assess the susceptibility of sesame genotypes for mechanized harvesting.

Table 1
Indices for susceptibility to mechanical harvesting of non-squander sesame genotypes at inertial force $F_{in} = 5\ 10^{-4}\ N$

Genotypes	Moisture content of seed, i_1		Moisture content of seed, i_2		Moisture content of seed, i_3	
	14.6 ÷ 15.1, %	9.9 ÷ 11.5, %	14.6 ÷ 15.1, %	9.9 ÷ 11.5, %	14.6 ÷ 15.1, %	9.9 ÷ 11.5, %
Aida	0.35	1.19	0.91	0.18	0.35	0.45
Nevena	1.36	1.50	0.28	0.34	0.25	0.17
Valia	2.32	4.81	0.20	0.18	0.16	0.02
Milena	0.87	1.82	0.39	0.23	0.35	0.20
4090	1.15	3.21	0.20	0.08	0.42	0.20
4079	2.06	2.33	0.16	0.25	0.23	0.30

Table 2
Losses of plot combine Wintersteiger at harvesting the sesame genotypes Aida, Nevena and Valya with moisture of seeds 15 ÷ 16%

Genotypes	Loses, %			
	Scattered by the header	Scattered by the thresher	Mechanically damaged	Total
Aida	16	6	17	43
Nevena	23	8	20	51
Valya	29	5	13	47

- To select the appropriate way of harvesting, this can be with or without breaking the capsules.
- For choice of parental pairs in the selection of new sesame genotypes, those are intended for mechanical harvesting.
- To synthesize the appropriate mechanical impacts for harvesting the seeds without their mechanical damage. That is usually done at construction and adaptation of harvesters.

Conclusion

There has been given proof of three indexes, which are objective criteria for assessing susceptibility for mechanical harvesting of the sesame genotypes. Their figures show that the genotype Aida is most suitable for mechanized harvesting. Sadly, its indexes differ significantly from those of the genotype, which is ideal for mechanized harvest.

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