Investigation of seed losses at mechanized harvesting of sesame

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Abstract

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The losses of sesame seeds of Bulgarian varieties Aida and Nevena by the Wintersteiger – Hege 160, by the specialized device for feeding sesame stems in harvesting machine and by the wind has been investigated. The results testify that the percentage of losses by the specialized device is 1.7 to 4 times smaller than by the header of grain harvester for both varieties. The wind, with a speed of up to 10.3 m/s for two days during the sesame maturation, scatters from 14.1% to 22.5% of the seeds depending on the variety and its moisture content. When the sesame is harvested after a wind at mentioned speed then a decrease in the percentage of seed losses is registered. It is twice for the specialized device and from 5 to 7 times for Hege 160.

Keywords: sesame; mechanized harvesting; losses

Introduction

Most of the sesame areas in the world are harvested manually because of the large losses of seed during harvesting by grain harvesters (Langham, 2014; Trifonov et al., 2013). In previous studies were reported losses from 15% to 65% which depend on three groups of factors (Adhir**,** 2003; Ishpekov et al., 2015):

– The first group includes the factors that influence on susceptibility of sesame varieties for mechanized harvesting;

– In the second are factors that characterize the mechanical impact of harvesting machine on plants;

– The third group integrates the weather indicators during harvest (Delibaltova & Dallev, 2017).

Significant selection work is carried out around the world to improve the susceptibility of sesame varieties for mechanized harvesting (Langham, 2008; Stamatov & Deshev, 2018). A lot of sesame varieties have been created that hold seeds in capsules at maturation. These varieties scatter their seeds much less at mechanical harvesting, but the losses are still considerable (Langham, 2014; Stamatov et at., 2018).

The header of grain harvester scatters sesame seeds due to the way of impact on plants. The reel penetrates between plants from above and wedges between the central stem and lateral branches because of the sharp angle between them. The wedging causes sharp bending of plants and release of seed by capsules (Queiroga et al., 2019; Langham, 2014). Before cutting of stems, the cutter bar shakes them sideways with the working frequency of blades, which also causes seed scattering. A significant amount of seed remains on the cutting apparatus and after accumulation falls over the soil (Figure 1).

At the Agricultural University of Plovdiv (Bulgaria) has been developed a specialized device for feeding the harvesting machine with sesame stems of non-scattering varieties which open capsules at maturation (Ishpekov et al., 2019). It catches stems laterally, tilts them lightly over a platform and then cuts them from the root. The device collects seeds that leave the capsules due to the mechanical impact on stems.

The third group combines the weather indicators – air temperature and humidity as well as wind speed. The weather during the sesame maturation is usually dry thus the most important factor in this group is the speed of the wind. At

Fig. 1. Sesame seeds on the cutting apparatus at harvesting with grain harvester

Fig. 2. Investigation the sesame seeds losses by Wintersteiger – Hege 160 and by the specialized device in 2018

variable speed and direction, it shakes plants sharply which leads to seeds catering.

The purpose of the study was to determine the percentage of sesame seed losses by the grain harvester header, by the specialized device, and by the wind.

Materials and Method

The study was carried out with the non-scattering Bulgarian sesame varieties Aida and Nevena, which open the tops of capsules at maturation (Stamatov et al., 2016). Prior the study was determined the moisture content and the biological yield of seeds. Moisture content was determined for all seeds of 10 randomly selected plants of each variety through the weighing method. Biological yield was calculated through the average yield of one plant and their number in one decade.

The percentage of seed losses by the specialized device and by the grain harvester Wintersteiger – Hege 160 was determined under an existing methodology (Ishpekov et al., 2019). Both machines were moved one after the other at equal speed and were harvesting sesame of one variety (Figure 2).

The controllable factor was the forward speed of both machines – v_M, which was changed to three levels. Kinematic coefficients of the grain harvester reel and of the feed-

ing chains of specialized device were maintained constant at λ=1.3 (Ishpekov et al., 2019). Two single factor experiments were conducted – first without any wind and second after a significant wind on the experimental field. Seed scattering by the wind was determined through the expression:

$$L_w = Y - L_h - S_h, \qquad (1)$$

where: L_w is the quantity of seed scattering by the wind, kg/da; Y – the biological yield of seed, kg/da; L_h – the quantity of seed losses by the harvesting machine, kg/da; S_h – the quantity of seed harvested by the machine, kg/da;

The quantity of seed losses by the grain harvester was denoted with D_{ak} and by the specialized device with D_a. The indices of expression (1) were calculated in relative units to the yield Y.

Results and Discussion

The study was conducted on the experimental field of IPGR – Sadovo. The wind speed was measured by the local weather station. In 2017 at sesame maturation was not registered significant wind, but in 2018 experiments were preceded by a wind with velocity of 2.0 to 10.3 m/s during two days. The biometric data for examined varieties are presented in Table 1. The biological yield over the two years differs by 10.9% for Aida and 11.6% for Nevena. The moisture

Table 1. Biometric data for the examined varieties

Variety	Plants in one meter	Capsules in one plant	Yield of one plant	Moisture content of seeds		Biological yield	
				2017	2018	2017	2018
	Number	Number	G	%	%	kg/Da	kg/Da
Ayda	14.01	80	5.22	8.5	8.8	93.1	104.5
Nevena	5.55	80	12.87	8.2	8.6	90.2	102.0

content and degree of maturity do not differ significantly for both varieties. These indicators predetermine the susceptibility of varieties to release seeds from capsules (Stamatov et al., 2016).

On Figure 3a and 3b are shown the polyethylene bands with seeds scattered by both machines. It is seen that there are only parts of stems and leaves on the band over which the specialized device has passed and a lot of seeds on the band over which the grain harvester has passed.

(a) **(b)**
Fig. 3. Seseme seed losses by the Wintersteiger – Hege 160 (a) and by the specialized device (b) in 2018

For the percentage of seed losses in 2018 were obtained the following regression equations:

By the grain harvester Wintersteiger – Hege 160
– *Ayda variety*

$$D_{ak} = 15.7419 - 23.0201v_M + 14.1196v_M^2 \qquad (2)$$

With coefficient of determination $R^2 = 0.95$ and probability $p_F = 0.0002 < 0.05$.
– *Nevena variety*

$$D_{ak} = 16.3056 - 22.7695v_M + 16.7260v_M^2 \qquad (3)$$

With coefficient of determination $R^2 = 0.96$ and probability $p_F = 0.0001 < 0.05$.

By the specialized device
– *Ayda variety*

$$D_a = 15.1141 - 29.2738v_M + 14.6217v_M^2 \qquad (4)$$

With coefficient of determination $R^2 = 0.97$ and probability $p_F = 0.0001 < 0.05$.
– *Nevena variety*

$$D_a = 21.5702 - 38.9479v_M + 21.15047v_M^2 \qquad (5)$$

With coefficient of determination $R^2 = 0.96$ and probability $p_F = 0.0001 < 0.05$.

The equations for seed losses by the specialized device, by Wintersteiger – Hege 160 and by the wind with a speed up to 10.3 m/s are presented in Figures 3 and 4 and the results of the expression (1) – in Table 2. It is seen that when changing the forward speed from 0.6 to 1.3 *m/s* then the losses by Hege 160 and by the specialized device varied from 1% to 4% for both varieties in 2018. Obviously, at a constant kinematic coefficient, the forward velocity impacts poorly on losses when harvesting is after a wind at a speed up to 10.3 m/s.
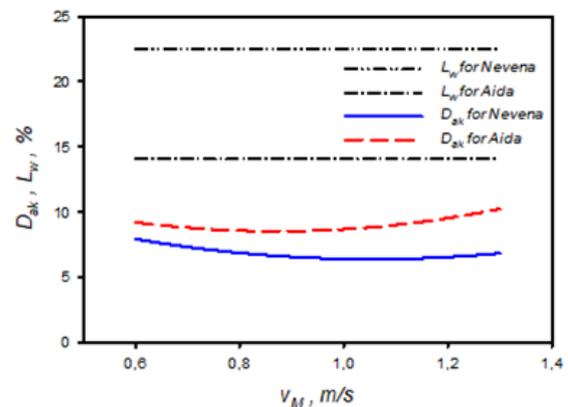

Fig. 4. Seed losses by Hege 160 and by the wind with a speed from 2.0 to 10.3 m/s in 2018
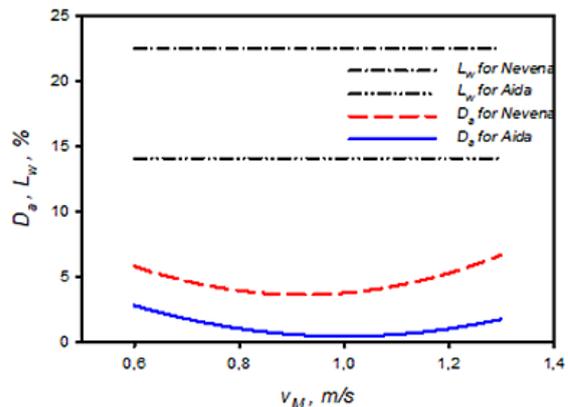

Fig. 5. Seed losses of seed by the specialized device and by the wind with a speed from 2.0 to 10.3 m/s in 2018

Quite different are seeds losses of both machines especially when harvesting without any preceding wind. In 2017 seed losses by Hege 160 was 21.2% for Aida and 30.2% for Nevena variety. The losses by the specialized device were 4 times less for Aida and 2.6 times for Nevena.

Table 2. Seed losses by the Hege 160, by the specialized device (SD) and by the wind with a speed up to 10.3 m/s as a percentage of biological yields at harvesting without a previous wind in 2017 and after a wind in 2018

Variety	Harvested in 2017		Harvested in 2018		Scattering in 2017		Scattering in 2017		Wind scattering
	Hege 160	SD	Hege 160	SD	Hege 160	SD	Hege 160	SD	
	%								
Ayda	78.8	94.8	79.4	83.6	21.2	5.2	7.1	2.3	14.1
Nevena	69.8	88.6	68.6	72.1	30.2	11.4	9.3	5.4	22.5

In 2018 after a wind with a speed up to 10.3 m/s was registered that Hege 160 loses 7.1% of Aida seeds and 9.3% of Nevena. The wind has scattered 14.1% from the seed of Aida and 22.5% of Nevena variety. Seed losses by the specialized device were 3 times less for Aida and 1.7 times for Nevena (Table 2).

These results show effects of the mechanical impacts and of the wind on seed scattering as well as the role of the variety. The indices i_2 and i_3 for both varieties are approximately equal at a same moisture content of the seed (Ishpekov & Stamatov, 2015; Stamatov et al., 2016). This means that both varieties have an equal percentage of retained seeds due to the placenta attachment and the anatomical features of capsules. But in the study, seed scattering by the wind for Nevena variety was 8.4% more which can be explained by two reasons. Nevena variety ripens 3 days earlier than Aida however the seed scattering was measured in one day. The second reason is in the duration of the ripening period, which for Nevena is 15 – 17 days and for Aida 8 – 10 days (Stamatov & Deshev, 2018). In practice, this means that capsules of Nevena variety are open and seeds are exposed to the wind for a longer period than those of Aida variety.

The overall percentage of losses was roughly equal for 2017 and 2018. For Aida it was 21.2%, and for Nevena 30.2% and 31.8% respectively. At harvesting without a previous wind, the losses were mainly due to the harvesting machine. At harvesting after a wind, losses were distributed between two causes – by the wind and by the harvester. In 2018 the wind was at a speed of 10.3 m/s and has become the main cause of seed scattering. This makes it possible to register the losses by harvesting machine close to zero because no seeds left in capsules after a strong wind.

The obtained results show the percentage of seed losses at maturation of sesame by the all main factors. Decreasing of losses can be expected after selection of new varieties whose plants mature together or after defoliation. The effect of this approach may be a subject of future research.

Conclusions

The forward speed of the machine does not have a strong effect on seed losses when the kinematic coefficient is equal to 1.3 for both the reel of the gain harvester and the feeding chains of specialized device. The type of mechanical impact on plants has a very strong effect on seed losses. For this reason, the specialized device causes from 1.7 to 4 times fewer losses than the harvester header.

The wind with speed up to 10.3 m/s for two days during the maturation of sesame scatters from 14.1% to 22.5% of the seed which depends on the variety and its degree of maturity. When sesame is harvested after a wind with a speed of up to 10.3 m/s, then the percentage of seed losses reduces twice for the specialized device and from 5 to 7 times for Hege 160, because part of the yield has already blown away by the wind.

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