

INVESTIGATION THE INDICES FOR MECHANIZED PICKING SESAME CAPSULES

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Abstract

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The picking of a single capsule from the sesame stem at its full and technological maturity by static force and shock impact has been experimentally investigated. The impact was applied in each of three main directions: downwards the stem axis, upwards the stem axis and across the stem. It was determined that the static picking force is from 5.5 to 10 times less energy consumable and has a duration from 14 to 33 times longer than the shock impact. The suitable impact directions are downwards the stem axis and across the stem. The application of each of them requires supporting the plant with respect to prevent its throwing down the soil surface. The upwards directed impact is not recommended for picking of a single capsule, because of its higher energy consumption. More over it is inapplicable for the capsule at technological maturity, because it leads to capsule destruction and seeds scattering.

Key words: sesame, mechanized harvesting

Introduction

Sesame seeds are very useful for the human health, but are harvested manually, because they leave the capsule very easy at maturity. For this reason, a couple of sesame genotypes with nondehiscent capsules have been selected at the Institute for Plant and Genetic Resources "K. Malkov" – Sadovo. This is the main prerequisite for mechanizing the capsules harvesting and thrashing them thereafter (Georgiev, 2002).

The present investigation has been conducted to investigate the indices for single sesame capsules picking with respect to determine the opportunities for their mechanized harvesting.

Materials and Methods

The indices were determined experimentally for matured capsules and for capsules at technological maturity. Two kinds of impact for capsule picking were used either by static force or by shock, which has been applied in the three main directions: downwards the stem axis, upwards the stem axis and across, perpendicular the stem.

The static force was measured by four dynamometers with different ranges in field conditions. Each measurement was conducted in twenty replications, which were used to calculate the mean value - \bar{X} and the standard deviation - σ of the picking force.

The shock parameters were assigned and measured by the stand, which was used for determining the indices for capsules breaking up (Ishpekov, 2008). The stand consists of a pendulum apparatus and a data acquisition system 9, 10 of "National Instruments" company USA (Figure 1) (Ishpekov, 1997). A sesame stem with a tested capsule was fixed to the stand foundation through two clamps 1, 7. The tested capsule 4 and the striker 3 were put in the equilibrium pendulum position. During the measurement it was been turned aside at fixed angle and then hit a capsule. This test was replicated ten times with respect to determine the percentage of the picked capsules - D, % and the consumed energy dE, J, depending on genotype and humidity of capsule, as well as, on the direction and the impulse of the impact. Its parameters were calculated through the mechanical characteristics of the pendulum and the signal from the data accusation system.

The experiments were conducted with capsules that were situated at the low and the middle zone of the stem from the following genotypes:

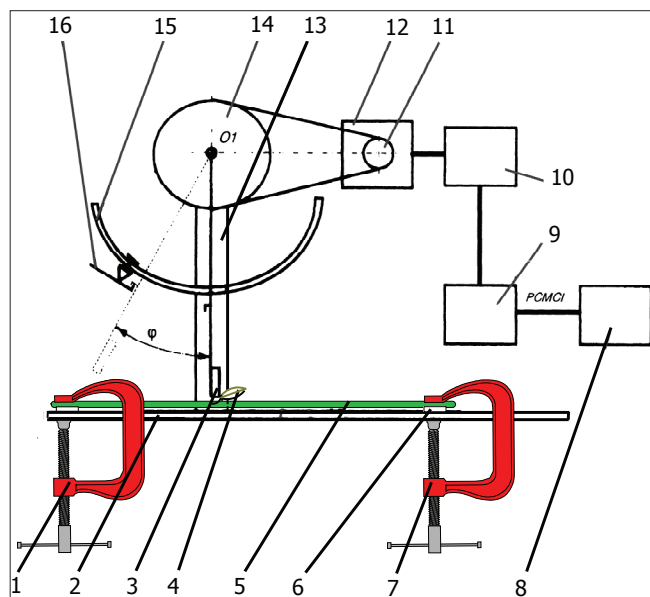


Fig. 1. Stand for measuring the indices for shock picking of a capsule from the sesame stem

1, 7 - clamps, 2 - foundation, 3 – pendulum with striker; 4 - capsule; 5 - sesame stem; 6 - plate, 8 - computer; 9, 10 - data accusation system "National Instrument" NI-DAQ-E50; 11, 14 - belt wheel; 12 - incremental encoder; 13 - pillar; 15 - angle scale, 16 - trigger

- Victoria, Irina and Sadovo - 4094, which are with nondehiscent capsules;

- Victoria at technological maturity and the variety Sofia, which at technological maturity is also with nondehiscent capsules, but become dehiscent at maturity.

It was made a comparison of impact parameters that cause the capsule picking and these that lead to its break off and seed scattering (Ishpekov, 2008).

Results and Discussion

The static force for picking a capsule depends on their stage of maturity, humidity and the position on the stem and varies in wide range (Table 1). The force upwards directed could easily be applied while the plant is on the root, but has the maximal picking value. Its mean is 30.92 N for matured capsule and 41.99 N for capsule at technological maturity.

The force has the minimal picking value when is directed downwards. In comparison with the force directed upwards its mean is 5.5 times less for the capsule at technological maturity and 9.3 times less for the matured capsule. The picking force directed across is from 4.7 to 8.2 times less than the force directed upwards. It should be noticed that the application of force directed downwards or force directed across requires support of the plant. Otherwise, these forces could throw the stem down on the soil surface, because it has a few nodes. The picking force for a capsule at technological maturity is from 1.36 to 2.34 times higher than for a matured capsule and is more dispersed.

The experimental data evidences that the picking force for a capsule situated at the low stem zone is higher than for a capsule at the middle stem zone. Their means differ up to 15.2 % for the matured capsule and up to 36.4 % for capsule at technological maturity. These differences are significant at level 0.05, but are not essential for proofing of the appropriate picking force.

It was determined from the data acquisition system that the capsule movement during its picking from the stem is about 1 mm and has duration of 1 s. Let us presume that for capsule picking is applied the work principle of the existing units and the capsules location at stem allows picking 4 pieces simultaneously. In that

Table 1
Static forces for picking single sesame capsule from the stem

Genotype	Force, N					
	directed upwards		directed downwards		directed across	
	\bar{X}	σ	\bar{X}	σ	\bar{X}	σ
a) for capsule at technological maturity with a humidity of 30.2 - 37.6 %						
Victoria, Sofia	41.99	21.5513	7.61	1.7567	8.86	0.6472
b) for matured capsule with a humidity of 11.7 - 12.4 %						
Victoria, Irina, Sadovo - 4094	30.92	13.7810	3.32	0.7775	3.78	0.5891

case for picking the all capsules from the stem, which numbers are from 87 to 231 (Stamatov, 2006), we can calculate the required duration for picking all of them. Thus, the required duration for picking up all capsules from one stem through a static force requires from 22 to 58 seconds. For doing this through a force directed downwards or across (Table 1) we receive the mean picking energy of 0.031 J for a matured capsule and 0.042 J for a capsule at technological maturity.

The shock parameters for capsule picking also depend on their maturity and humidity. The picking a matured capsule from Victoria variety with humidity of 11.7 % was initiated at an impulse over 0.42 N.s by either shock directed downwards or shock directed across the stem (Figure 2). This phenomenon for the shock directed downwards was observed at impulse over 0.45 N.s. All capsules was picked by the impulse over 0.58 N.s for both shocks - directed downwards or across and by an impulse over 0.73 N.s for the shock directed upwards. For the same variety at technological maturity with humidity of 37.6 % the capsule picking was initiated at an impulse over 0.44 N.s by the sock directed downwards. For the across shock this was observed at approximately equal impulse $S \geq 0.50$ N.s. All capsules at technological maturity was picked by a shock directed downwards with an impulse over 0.73 N.s or by across shock with an impulse over 0.83 N.s. When the shock was applied upwards with an impulse of 0.83 N.s, then 60 % of the capsules were picked and the rest were broken by the impact.

The required shock impulse for picking all capsules at technological maturity was significantly higher than for matured capsules. For Victoria variety this difference was the biggest for the shock directed upwards, when was not attained picking all capsules (curve IV,

Figure 2). The difference for the shock directed downwards was 25.9 % and for the shock directed across was 43.1 %.

The results from another investigation (Ishpekov, 2008) showed that nondehiscent matured capsule had been broken by a shock impulse higher than 0.65 N.s. It had been also observed the single seeds abandonment at shock impulse over 0.25 N.s, because of instantaneous opening the capsule. Obviously, the both picking impulse and breaking impulse had very close values for capsule at technological maturity knocked by a shock directed upwards. Moreover, for Sofia variety at the same conditions, the picking impulse was higher than the breaking impulse up to 27.7 %. The ratio between compared impulses became opposite for the shock directed downwards or across. In those cases picking

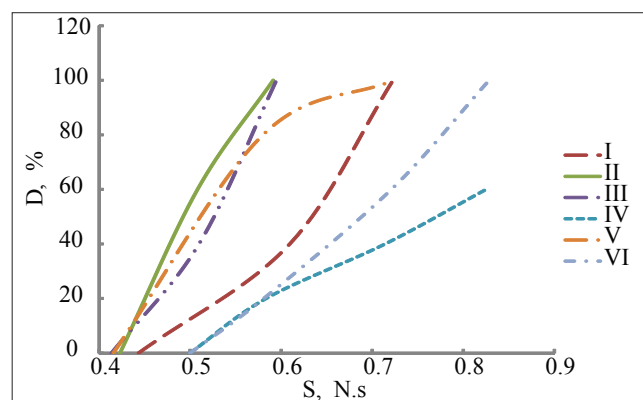


Fig. 2. Percentage of picking capsules depending on shock impulse S for capsule of Victoria variety
 I and IV - shock directed upwards; II and V - shock directed downwards; III and VI - shock directed across;
 I, II, III - for matured capsules with a humidity of 11.7 %;
 IV, V, VI - for capsules at technological maturity with a humidity of 37.6 %

impulses were lower than the breaking impulse up to 12.1 %.

The percentage of the picking capsules D of Sofia variety at technological maturity with a humidity of 32.5 % is presented at Figure 3. It is seen that the capsule picking has been initiated by:

- a shock directed downwards with an impulse over 0.44 N.s;

- a shock directed upwards or across with an impulse over 0.78 N.s, which is 77.3 % higher.

All capsules were picked by a shock directed downwards with an impulse over 0.59 N.s. Up to 80 % of the capsule were picked by the shock directed across and barely 20 % of the capsule were picked by a shock directed upwards. The rest of the capsules were broken at a shock impulse over 0.82 N.s.

The matured capsules of Sadovo - 4094 with humidity of 11.8 % were picked through a shock impulse with different value (Figure 4). The capsule picking was initiated by an impulse in the interval 0.05 - 0.13 N.s for either of the tree shock directions. All capsules were picked at an impulse more than:

- 0.35 N.s for the shock directed upwards,
- 0.18 N.s for the shock directed downwards,
- 0.26 N.s for the shock directed across.

The mentioned picking impulse values are less than the capsule breaking impulse, but also cause scattering single seeds (Ishpekov, 2008).

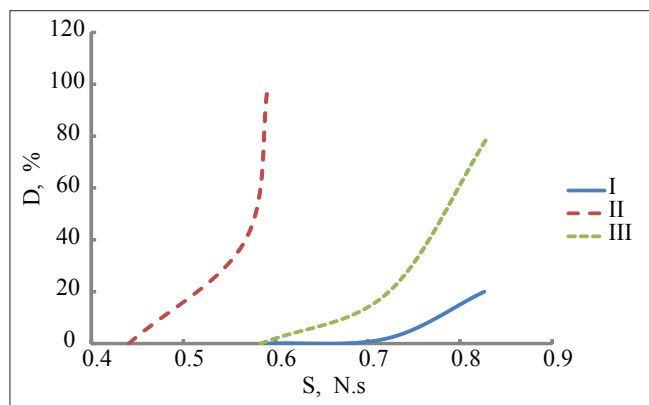


Fig. 3. Picking percentage D depending on shock impulse S for capsule of Sofia variety at technological maturity with a humidity of 32.5 %

I - for impact directed upwards; II - for impact directed downwards; III - for impact directed across

The energy consumption for picking single capsule also depends on maturity, shock direction and impulse value (Figures 5, 6, 7). The maximum energy was required for picking a capsule at technological maturity by the shock directed upwards. Its value for Victoria variety was 0.49 J, and for Sofia variety 0.84 J. The picking energy consumption has the minimum for matured capsules at shock directed downwards. Its values reached up to 0.2 J for Victoria variety, up to 0.25 J for

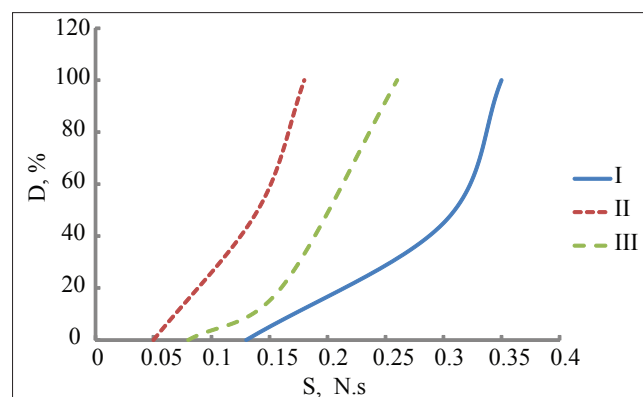


Fig. 4. Picking percentage D depending on shock impulse S for matured capsule of Sadovo - 4094 genotype, with a humidity of 11.8 %

I - for impact directed upwards; II - for impact directed downwards; III - for impact directed across

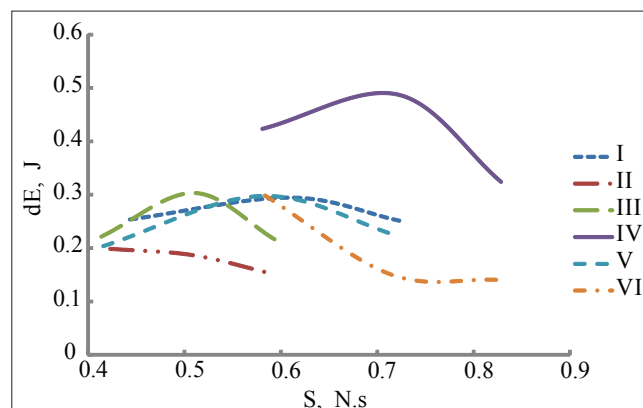


Fig. 5. Energy consumption dE for capsule picking depending on shock impulse S for Victoria variety

I and IV - for impact directed upwards; II and V - for impact directed downwards; III and VI - for impact directed across; I, II, III - for matured capsule with a humidity of 11,7 %; IV, V, VI - for capsule at technological maturity with a humidity of 37.6 %

Sofia variety and up to 0.16 J for Sadovo - 4094. For the shock directed across these values were increased with 4 % for Victoria variety, with 12 % for Sofia variety and with 9 % for Sadovo - 4094.

Each graph of picking energy consumption has a maximum. It was not reached for Sofia variety, because of the breaking the capsules by the impact. The minimum energy consumption is observed at the impulse value, which leads to picking all capsules (Figure 6). This is explicable, because the impulse and the consumed energy are predetermined by the speed of the shock. Its values at which all capsules have been picked are presented in Table 2.

The experimental results evidence that the shock picking of matured capsule was done with minimum impulse and minimum energy consumption at the impact directed downwards. Unfortunately this impact could demolish the sesame stem and make impossible

mechanized harvesting of capsules. In case of provided support of the stem, it is suitable to apply shock impact directed across with a velocity more than 1.74 m.s^{-1} for matured capsules and more than 2.54 m.s^{-1} for capsules at technological maturity.

The measurement system showed that the duration of shock picking for a capsule from stabilized stem was 30 - 70 ms. This means that the duration for picking all capsules from the stem is 2.6 - 16.2 s.

The experimental results prove real possibilities for picking sesame capsules by static force as well as by shock impact. In comparison with the shock impact, the static force requires 5.5 to 8.7 times less energy for picking a matured capsule and from 5.8 to 10 times for picking a capsule at technological maturity. The ratio between picking durations and energy consumptions became opposite for capsule picking by a shock impact. Obviously, for choosing of an impact for picking

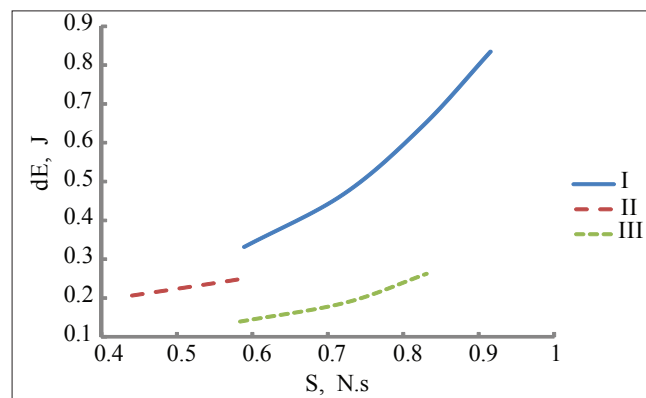


Fig. 6. Picking energy dE depending on shock impulse S for capsule at technological maturity of Sofia variety with a humidity of 32.5 %

I - for impact directed upwards; II - for impact directed downwards; III - for impact directed across

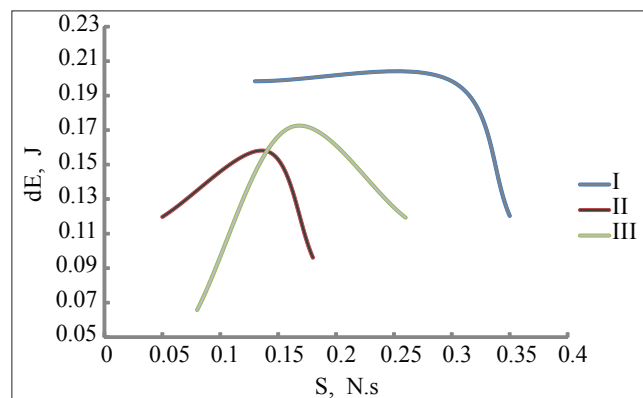


Fig. 7. Picking energy dE depending on shock impulse S for matured capsule of genotype Sadovo - 4094 with a humidity of 11.8 %

I - for impact directed upwards; II - for impact directed downwards; III - for impact directed across

Table 2

Minimal speed for picking single sesame capsules by a shock impact, m.s^{-1}

Shock	Capsule genotypes			
	Victoria with a humidity of 11.7 %	Victoria with a humidity of 37.6 %	Sofia with a humidity of 32.5 %	Sadovo - 4094 with a humidity of 11.8 %
impact directed upwards	2.11	*	*	1.77
impact directed downwards	1.72	2.10	2.45	1.54
impact directed across	1.74	2.42	2.54	1.64

*In those cases the capsule was broken by the shock of the pendulum.

a capsule from sesame stem should make a compromise between its energy consumption and productiveness.

The results received could be useful for proofing of a unit for mechanized harvesting of sesame capsules. As a difference from the investigation conditions it should be foreseen that the plant in the field is grounded on its root only and can be shaken by a small impact.

Conclusions

The picking of single capsule from sesame stem by pulling requires relatively big static force directed upwards. Its mean value for a matured capsule is 30.92 N and for a capsule at technological maturity is 41.99 N. The required forces directed downwards or across are less up to 8.2 and 9.3 times respectively. However, the application of either of them requires additional stem stabilization.

The shock capsule picking could be made by impact directed downwards or across with an impulse more than 0.58 N.s and a velocity more than 1.74 m.s⁻¹. It is also possible to pick the capsule by an impact directed upwards, but its impulse and speed should be increased more than 25 %.

The picking of single capsule at technological maturity by a shock is recommended the impact directed downwards or across. This is not possible by the shock directed upwards, because in this case the impulse for picking is bigger than the impulse for breaking capsule. The recommended impacts require energy consumption

from 0.16 to 0.25 J for matured capsule and from 2.5 to 4.2 times more for capsule at technological maturity.

The capsule picking through static force requires from 5.5 to 10 times more energy consumption in comparison with a shock impact, but its duration is from 14 to 33 times longer.

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