Rinsing Device for Separating Seeds of the Species from the *Solanaceae* Botanical Family

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ABSTRACT

In the years 2013-2014, the research was carried out to develop a new rinsing device for separating seeds of the species from the *Solanaceae* botanical family. At first, the design was done, then, the prototype of wood was constructed. The machine was tested on the tomato seeds of the cultivar Frodo F₁ in the Polish seed company breeding tomatoes. The device allowed to increase seed germination in both series of trials. In case on cleaning seeds with the flesh, the seed germination in the best fraction improved from 56.2% (check) to 79.4%. In the case of the seeds only (without flash), the seeds germination improved in the best fraction from 63.2 % (check) to 92 %. In both cases, it was due to lowering to amount of abnormal seedlings. Better quality of the graded seeds was followed by heavier seeds. The device needs further testing on the seeds of other cultivars and species.

Keywords: *seed fractions, seed quality grading, seed rinsing, tomato seed production*

INTRODUCTION

Production of seeds of high quality requires a large amount of work and often specialized equipment (Szpakowska, Hołubowicz 2012). The first step of processing takes place already in the field when the harvesting is done (Copeland, McDonald 1985). The processed seeds should be dry and healthy (Domoradzki, Korpala 2004). Seed cleaning can be divided into 3 stages: primary, basic and individual. The first one includes removing the biggest and heaviest impurities, whereas the basic one uses the same set of machines for different species of seeds. Individual seeds cleaning focuses on selected characters of a given species in order to clean them up to required quality standard, e.g. colour or shape (George 1985; Kelly, George 1998).

Tomato has been the most important vegetable species in the world (FAO 2014). Every year, in the world, there are about 33 million tons of tomato fruits produced, i.e. 10 % of the total area of all vegetable species (Bocian 2006). In 2014, there was an increase in this production to almost 39 million tons (Anonymous 2014). Production of tomato fruits in Poland also increased from 312

(2000) to 760 thousand tons (2012) (FAOstat 2014). This large production needs both good cultivars and seeds. Tomato seeds, before they go on sale, require additional processing and conditioning work (George 1985; Kelly, George 1998). At first, they must be extracted from the fruit pulp. To do so, it is necessary to ferment the pulp with seeds. The pulp with the seeds is then rinsed with water. Seed companies use special machines for it. The whole process consists of three steps: fermentation, the rinsing the pulp with water and centrifugation to remove water and residues (Demir 1994). This method effectively separates the seeds from the pulp but further processes require drying the seeds. Seed companies breeding tomato and producing its seeds have been looking for new devices to minimize the time and cost of production and maximize profits (Hołubowicz, Cieślak 2005). Such devices will not only lower the costs of tomato seeds production, but should also improve the final seed quality.

The objective of this experiment was to design, build and test a rinsing device for separating seeds of the species from the *Solanaceae* botanical family while improving the quality of seeds.

MATERIALS AND METHODS

The rule of working of the designed machine is based on differences in the seeds' weight. Good tomato seeds are heavy and large and germinate well. Bad seeds are light and small and germinate poorly. If we place the seeds into water, light seeds will float on the surface, whereas the heavy ones will sink to the bottom. The designed device follows this rule.

In the designed device, the water tube of the machine is divided into 3 equal compartments called chambers (fig. 1). The whole structure

is inclined at a slight angle which causes the movement of water along the chambers. This way, it is possible to grade seeds. The best of them, i.e. the biggest and the heaviest ones, stay in the first chamber, while the worse ones stay in the second one. The seeds in the third chamber are of the lowest quality. The last fractions of poorly filled seeds are washed out of the machine along with the fruit flesh and water. The prototype machine was built of the standard building plate. Its dimensions were: 100 cm long, 40 cm wide, 30 cm high. The chamber walls were 20 cm high.

Tab. 1. The average air day temperature (C°) and month sums of precipitation (mm) in Kutno experiment station (the place of the tomato seed production) in 2014 and the mean values of the same parameter for the years 2005- 2010

month	Average air day temperature		Sums of precipitation	
	2014	2009- 2013	2014	2009- 2013
May	14	13.8	73.2	112.36
June	16	17.2	65.6	80.84
July	21	19.2	39.4	65.68
August	19	18.8	14.2	50.52

For the results, the variance was calculated. The significant differences were calculated based on the Duncan test for $\alpha = 0.05$.

Fig. 1. Diagram of a rinsing device for separating seeds of the species from the *Solanaceae* botanical family.
1-feed hopper; 2- water tube; 3- compartments for seeds grades; 4- removing light seeds, fruit flesh and water;
5- adjusting supporting stick

The device was bent at an angle of 15°-20° to the ground. The stream of water was adjusted by hand and depended upon the cultivar seed lot, size and weight of seeds.

The final evaluation of the device was done in the plant breeding and seed production company "PlantiCo Zielonki", unit in Gołębiew n. Kutno (Middle Poland) specializing in tomato breeding and seed production. It was done on the cultivar Frodo F₁. It is newly developed, early cultivar, with the vegetation period 66-75 days. It is high yielding, with medium size fruit, 70-80 g each, well coloured and hard. They do not crack and are resistant to transportation. The cultivar was developed for processing and mechanic harvesting of for the fruit. It has high dry matter connect (Anonymous 2013).

When the prototype was constructed, the fermented flesh with seeds and pure seeds were then used to verify it in practice. In 2014, in middle Poland, the weather conditions for tomato seed production, were good or very good. Although, due to cold June, it started badly, eventually it came out to be good or very good. The mean day temperatures June 2014 were lower than the values for the last 5 years (Table 1). These values for July 2014 were though higher than the ones in last 5 years. Through the vegetation in 2014, monthly sums of precipitations were smaller than the values for the last 5 years. This weather created good or very good conditions for seed development and maturation.

The seeds, when separated on to the device, were either not separated (control- C) or divided into 4 fractions (F1- F4). Two independent evaluation trials of the device took place: 1) the

first one on the raw flesh with seeds pulp just after fermentation, and 2) on pure seeds already separated from fruits flesh and skins (called BS). After using the device, all the seeds were dried on the blotter paper at 25°C for 2 days.

In laboratory test, seed germination energy and capacity as well as 1000 seeds weights were evaluated. Additionally, also abnormal seedlings were counted. The used seed testing methods followed the ISTA rules (Anonymous 2012). The tests were done in the 3 replications of 100 seeds. The 1000 seeds weights tests were done in 1 replication of 500 seeds.

RESULTS AND DISCUSSION

The carried out experiment proved that the rinsing device improved the seeds quality in both cases: with raw pulp and pure seeds (Phot. 1, Fig.1 and 2). In case on cleaning the seeds with the flesh, the seed germination in the best fraction improved from 56.2% (check) to 79.4%. In the case of the seeds only (without flash), the seeds germination improved in the best fraction from 63.2 % (check) to 92 %. In both cases, it was due to lowering to amount of abnormal seedlings. It was followed by differences in 1000 seeds weights (data not shown).

The tomato seeds fermentation, although simple technically, is not always the same. In many years, especially with bad weather, it may result in the fermentation mass full of pieces of fruit flesh, water and skin. In this case, it is also important to separate first the seeds from the remains and then, such pure seeds, should be separated again. Sometimes, it is also related to the given cultivar (George, 1985).

*Means followed by the same letters are not significantly different at $\alpha = 0.05$ level according to Duncan's test

Fig. 1. Effect of grading tomato seeds of the cultivar Frodo F₁ with the rinsing device on their germination and abnormal seedlings [%]. C- control, F1- F4- seed fractions from raw fermentation pulp

* Means followed by the same letters are not significantly different at $\alpha = 0.05$ level according to Duncan's tests

Fig. 2. Effect of grading tomato seeds of the cultivar Frodo F₁ with the rinsing device on their germination and abnormal seedlings [%]. C- control, F1BS- F4BS- seed fractions, from pure seeds.

Fig. 3. Tomato seeds grading with the use of rinsing device. Left: seeds with the fermented fruit flesh. Right: seeds without the flesh

For many years, tomato has been the most important vegetable in the world. Its area and production have been increasing (FAOstat 2015). The tomato market has dominated by hybrid

cultivars despite their high cost. As a result, tomato growers started to limit amount of seeds used for sowing, or use ready transplants. They also started to use the seeds of the highest weight, and enhanced quality (Hill *et al.* 1989, Bocian, Hołubowicz 2008ab).

The use of the tested rinsing device allowed to improve the quality of the graded tomato seeds in comparison with the check ones. It came from combining preliminary cleaning with the seed grading. After using the rinsing device, the seed lot was divided to four fractions. Better quality of the graded seeds was followed by heavier seeds. A new approach to cleaning tomato seeds consists in grading them already during the extraction, not after drying them. So far, tomato seeds were graded after drying them (Bocian 2006, Domaradzki, Korpala 2004, Poćwiardowski *et al.* 2011). This way, actually seed processing was shorter and thereby also cheaper. This, in turn, is in agreement with the leading strategy of marketing based on lowering seed production costs (Mumby 1994). What are the advantages of using the developed rinsing device over so far used seed production technology? We see three of them: 1) the seeds can be graded already during extraction, not after drying, 2) the seed mass can be limited at earlier stage than before 3) the whole process of seed cleaning and grading could be shorter. Although, last 20 years, many complicated, sophisticated and expensive machines for seed cleaning have been developed (Szpakowska, Hołubowicz 2012), still simple and cheap devices could be designed and introduced to help solving this problem.

The presented in this paper device, although effective in cleaning and grading of solely one cultivar and one species, still needs further practical testing on other tomato cultivars and other vegetable species.

CONCLUSIONS

The developed rinsing device made possible to grade tomato seed lot into 4 fractions of different quality.

In case on cleaning seed with the flash, in the best fraction, the seed germination improved from 56.2% (check) to 79.4%.

In the case of the seeds only (without flash), in the best fraction, the seeds germination improved from 63.2 (check) to 92 %.

Better quality of the graded seeds was followed by heavier seeds.

The increase of germination of the tested tomato seeds was due to lowering the number of abnormal seedlings.

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