

Evaluation of industrial tomato genotypes in open-field production

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Abstract. Recently, industrial tomato production in Hungary shows an increasing tendency after a weak processing period. However, to maintain the cultivation profitable, the use of proper technology and genotype is indispensable.

In the experiment, five hybrids and one variety were evaluated in a plot experiment design on open field. The main objective was to evaluate the fruit quality of different genotypes and to determine the suitability for mechanical harvest.

According to the results, *Heinz 1015 F₁* and *Heinz 9478 F₁* had the best fruit quality for industrial processing.

Nowadays, the use of hybrids with good adaptability and resistance properties is important for a profitable production.

Keywords: economic value, quality examination, sensory, profitable production, evaluation

1. Introduction

At present, tomato has one of the largest producing areas worldwide, and it is indispensable not only for fresh market but for the industry as well [3]. It is an especially fast-developing sector: in a little more than a decade, it has grown by 49% [1]. According to the statistics, the total growing area is more than 4.8 million hectares worldwide, of which a little more than 182 million tons were harvested [2]. Tomato is important not only worldwide but in Hungary as well.

In Hungary, the total production area of industrial tomato was 2,200 hectares in 2017, of which nearly 185 thousand tons were harvested [4]. All produced tomato is processed in Hungarian factories [5]. Univer, which is the principal

tomato-processing company in Hungary, was the 37th in the world ranking in 2018 [7].

Currently, the main problem is the low takeover price and the rise of production prices. The minimum production value is 70 tons per hectare. Thereby, to make production profitable, the yield has to reach 100 tons per hectare [6].

2. Materials and methods

The experiment was carried out at the University of Debrecen, Farm and Regional Research Institute, Botanical and Exhibition Garden, on an open field in 2017. The soil type was lowland chernozem. After the harvest, different quality parameters were examined on the berries.

Experiment progress

In order to have representative results, the following six genotypes were evaluated: *Heinz 1015 F₁*, *Heinz 9478 F₁*, *NUN 254 F₁*, *Prestomech F₁*, *Rustico F₁*, and *Kecskeméti 407*. The planting date was 5 May 2017. The parcel size was 80 × 45 cm with 21–30 plants. Harvesting was carried out on 30 August 2017.

Conducted measurements

The measurements were conducted immediately after the harvest. The following physical parameters were evaluated: fruit shape index (length/diameter), weight of berries (g/piece), yield of plants (g/plant), water-soluble dry matter content (Brix%) with hand refractometer (PAL-BX/RI), and firmness of the berries (g cm⁻²) with Magness-Taylor pressure tester. Furthermore, skin thickness was calculated – measuring the force needed to tear the skin (kg⁻¹) – with TA.XT Plus Texture Analyzer. The sensory evaluation was carried out for 12 properties, which were rated from one to five, by 15 persons.

3. Results and discussions

The berries were evaluated for different quality parameters right after the harvest. The main objective was to select the proper genotypes for the Hungarian growing conditions.

Fruit shape index

The shape of the berries during mechanical harvest is of utmost importance. The fruit shape index is the length of the berry divided by its diameter. If the result equals one, the berry is spherical. When the result is less than one, the berry is flat, and when the result is more than one the berry is oval. For mechanical harvest, the best shape is oval, with a fruit shape index between 1.0 and 2.0.

The fruit shape index of the evaluated genotypes is shown in *Figure 1* and the evaluated berries in *Figure 2*.

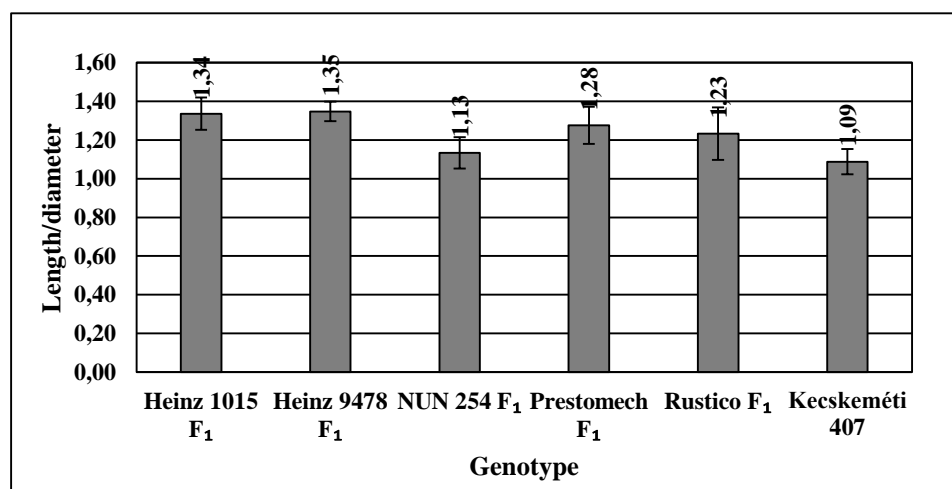


Figure 1. Fruit shape index of the evaluated genotypes



Figure 2. Fruit shape index of the evaluated genotypes

Heinz 1015 F₁ and *Heinz 9478 F₁* had the highest values, the average of the two genotypes showing no statistical difference. *NUN254 F₁* and *Kecskeméti 407* had the lowest values (1.13 and 1.09). *Kecskeméti 407*, the only examined open-pollinated variety, can also meet the requirements with its barely oval shape.

According to the results, all the examined genotypes are suitable for the industry, with a fruit shape index between 1.0 and 2.0.

Weight of the berries and yield per plant

Uniform berry weight plays a major role in harvesting: the key of successful mechanical harvesting is the similar shape and size of the berries, which is highly influenced by the weight of the berries. The other important parameter, which should be examined together with berry weight, is the yield of the plants.

Presently, the main goal is to reach 100 t ha⁻¹ yield to make the production profitable. To reach this objective, it is important to use proper genotypes, which have not only unified berry weight but proper yield as well.

In the last few years, the number of plants per hectare has decreased from 50 thousand to 35–38 thousand according to farmers' reports. This increases the need to choose genotypes with higher yield per plant.

The evaluated genotypes have different values, which are presented in *Table 1*.

Table 1. Marketable yield of the evaluated genotypes

	<i>Berry weight (g per piece)</i>	<i>Marketable yield per plant (g per plant)</i>
<i>Heinz 1015 F₁</i>	56.80 ± 8.02	2,712
<i>Heinz 9478 F₁</i>	64.08 ± 5.94	3,016
<i>NUN 254 F₁</i>	68.20 ± 5.22	1,636
<i>Prestomech F₁</i>	69.20 ± 4.96	1,587
<i>Rustico F₁</i>	62.70 ± 4.72	1,239
<i>Kecskeméti 407</i>	77.70 ± 9.35	560

Even though *Kecskeméti 407* had the lowest marketable yield per plant due to sunburnt foliage, it yielded the highest berry weight. However, the high standard deviation shows the non-uniformity of the variety, which can influence the mechanical harvest.

Regarding to berry weight, *Heinz 1015 F₁* had the lowest mean, and the standard deviation was rather high (56.80 ± 8.02 g). Meanwhile, the yield of the plants was especially good, the marketable yield being a little more than 2.7 kg per plant.

Concerning yield per plant data, the best result belongs to *Heinz 9478 F₁*, which produced a little more than 3 kg of marketable yield per plant (3,016 g).

Water-soluble dry matter content

One of the most important quality parameters of industrial tomato is the water-soluble dry matter content, which was evaluated after the harvest. This parameter and the proper harvesting time (before 20 August) determine the purchase price. The mentioned two parameters can alter the price both in a positive and in a negative way.

For the food industry, the required value is 5.0 Brix degree, above which the recipient raises the acceptance price. The other important value is 4.7 Brix degree: below this, the acceptance price decreases. The results of the evaluated genotypes are shown in *Figure 3*.

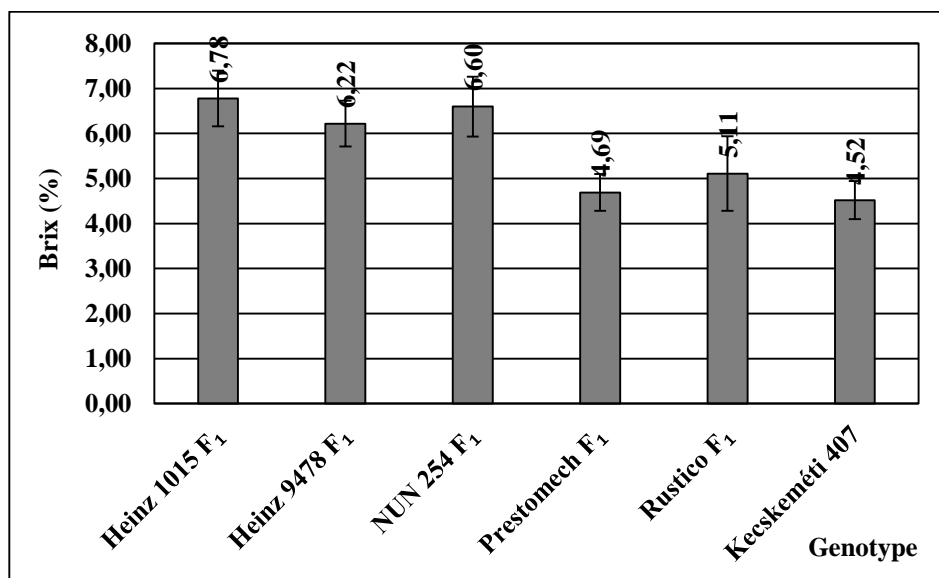


Figure 3. Water-soluble dry matter content (Brix%) of the evaluated genotypes

According to the results, the examined genotypes can be divided into two groups. In the first group, there are three hybrids: the firmly good *Heinz 1015 F₁*, *Heinz 9478 F₁*, and *NUN 254 F₁*, with high water-soluble dry matter content and higher than 6.0 Brix degree. In our growing circumstances, these hybrids were the most prosperous considering industrial production.

The other group was composed of the other three genotypes, *Prestomech F₁*, *Rustico F₁*, and *Kecskeméti 407*. The Brix values of these three genotypes are close to 5.0, only the *Rustico F₁* exceeding this value.

Firmness and skin thickness

Besides water-soluble dry matter content, firmness and skin thickness are two of the main quality parameters of industrial tomato. The berries have to be resistant against injuries during mechanical harvest and transport because injured berries begin to deteriorate very quickly. The results for the examination of these quality parameters are shown in *Table 2*.

Firmness must be at least 1,200 g per cm² to fulfill the requirements of the industry. All of the evaluated genotypes meet this value. However, there is no significant difference between the results of each hybrid.

The other important quality parameter is skin thickness, which can be measured by the force needed to tear the skin. It is at least as important from the viewpoint of damages as firmness. Skin thickness is the main quality parameter, which determines the resistance of the berries to mechanical injuries during the harvest and transport.

One of the evaluated genotypes had outstanding results: the *Kecskeméti 407* needed extremely high (0.680), nearly eight times stronger force to tear the skin compared to the evaluated hybrids. The hybrids needed nearly equal force to tear the skin, but none of them reached the value of 0.100 kg.

Table 2. Firmness and skin thickness of the evaluated genotypes

<i>Genotype</i>	<i>Firmness (g cm⁻²)</i>	<i>Skin thickness (kg⁻¹)</i>
<i>Heinz 1015 F₁</i>	1,601.9 ± 179.45	0.089 ± 0.018
<i>Heinz 9478 F₁</i>	1,458.0 ± 204.33	0.071 ± 0.015
<i>NUN 254 F₁</i>	1,333.0 ± 183.49	0.085 ± 0.022
<i>Prestomech F₁</i>	1,320.0 ± 115.95	0.067 ± 0.018
<i>Rustico F₁</i>	1,243.0 ± 107.61	0.083 ± 0.018
<i>Kecskeméti 407</i>	1,291.1 ± 118.04	0.680 ± 0.017

Sensory evaluation

As part of the experiment, sensory evaluation was carried out with 12 quality parameters.

Nowadays, the utilization of industrial tomato is becoming more and more widespread. In some cases, farmers can target the fresh market. In such cases, the detectable parameters are more important: costumers choose based on appearance; it is not possible to taste the products.

However, during industrial production, the quality parameters are more important because using less additives means better product quality and higher prices (additive-free and bio-products are more expensive).

According to our results, *Heinz 1015 F₁* and *Heinz 9478 F₁* had the proper quality parameters to fulfill the needs of the fresh market. Meanwhile, for industrial utilization, *Heinz 9478 F₁* had the best results in all but two parameters (Table 3).

Table 3. Sensory evaluation of the examined genotypes

	<i>Heinz 1015 F₁</i>	<i>Heinz 9478 F₁</i>	<i>NUN245 F₁</i>	<i>Prestomech F₁</i>	<i>Rustico F₁</i>	<i>Kecskeméti 407</i>
Appearance	4.40±0.52	4.70±0.48	3.70±0.67	3.80±1.03	4.00±0.67	4.00±0.47
Colour	4.60±0.52	4.80±0.42	3.40±0.70	4.30±0.48	4.60±0.52	4.00±0.67
Firmness	4.00±1.05	4.40±0.70	3.80±0.92	3.70±0.67	4.30±0.67	4.10±1.10
Sweet taste	3.50±0.71	3.60±0.84	2.90±0.57	3.00±0.67	3.00±1.15	2.80±1.32
Acidity	4.00±0.67	4.10±0.74	3.60±0.97	3.40±0.70	3.30±1.16	3.30±1.25
Tomato taste	4.20±0.63	4.00±0.82	3.10±0.74	2.90±0.57	3.40±0.84	2.70±1.06
Skin thickness	3.00±1.33	3.40±1.17	2.70±1.06	2.90±1.37	3.00±1.41	2.80±1.03
Consistency	4.00±0.82	4.50±0.71	3.70±0.95	3.90±1.20	4.20±1.03	3.90±0.74
Juiciness	3.20±1.14	3.50±0.97	3.50±1.08	3.40±1.17	3.30±1.06	3.40±1.07
Sour taste	3.90±1.60	4.00±1.63	3.40±1.58	3.20±1.48	3.40±1.43	3.00±1.63
Unpleasant aftertaste	4.70±0.48	4.80±0.42	3.90±1.45	4.40±0.70	4.10±0.74	3.90±1.20
Overall impression	4.10±0.74	4.40±0.52	3.30±0.95	3.60±0.97	3.50±0.71	3.10±1.29

4. Conclusions

Tomato has one of the largest producing areas worldwide. In the last few years, its growing area and yield have been increasing in Hungary as well.

Nowadays, the purchase price is rather low; therefore, the yield has to reach or exceed 100 t ha⁻¹ for a profitable production.

In the experiment, six genotypes were evaluated on open field. The measurements verified different quality parameters: fruit shape index (length/diameter), weight of berries (g/piece), yield of plants (g/plant), water-soluble dry matter content (Brix degree), firmness of the berries (g cm⁻²), skin thickness, and sensory evaluation.

Finally, we can state that the *Heinz 1015 F₁* and *Heinz 9478 F₁* hybrids were the most suitable ones for industrial production in our circumstances. These hybrids stood out with rather high water-soluble dry matter content (6.22–6.78 Brix degree), optimal fruit shape index (1.34–1.35), yield of plants (2,712–3,016 g), proper firmness (1,601.9 ± 179.45 and 1,458.0 ± 204.33 g cm⁻²), and skin thickness (0.089 ± 0.018 and 0.071 ± 0.015 kg⁻¹).

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