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Original scientific paper

ASSESSMENT OF DUTCH TOMATO HYBRIDS GROWN IN CONDITIONS OF WESTERN BOSNIA AND HERZEGOVINA

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Tošić I., Lj. Bošković-Rakočević, T. Predić, N. Pržulj, B. Savić, V. Trkulja (2018): *Assessment of Dutch tomato hybrids grown in conditions of Western Bosnia and Herzegovina*.- Genetika, Vol 50, No.3, 933 - 942.

The comparative estimation was carried out with seven tomato hybrids (*Lycopersicon esculentum* Mill.) during the period 2011 to 2013 in greenhouse at Agricultural Institute of Republic of Srpska, Banja Luka, Bosnia and Herzegovina. The aim of this study is to examine the dry matter content, lycopene in fruits and total yield of Dutch tomato hybrids in the conditions of western Bosnia and Herzegovina. The experiment was set up by a randomized block design in three repetitions. The dry matter content ranged from 5.60% to 8.14%. Hybrid and hybrid x year interaction had significant ($p<0.05$) influence on lycopene content and tomato yield. The factors that had a decisive influence on the content of dry matter, lycopene content in fruit and tomato yield were year, hybrid and cultivation technology.

Keywords: *Lycopersicon esculentum* Mill., hybrid, dry matter, lycopene, yield

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INTRODUCTION

In the world, tomatoes are grown on about 2.5 million ha (BECHAR *et al*., 2007). In 2012, in the Republic of Srpska, Bosnia and Herzegovina, 3.714 ha were planted under tomato with an average yield of 44 t/ha.

Tomato is the second most important plant species after potatoes (FAOSTAT, 2010). The selection of hybrids in the terms of yield is one of the most important factors in production technology. There is a wide assortment of different hybrids available (VAN DER KNAAP *et al*., 2013), and therefore the selection of appropriate hybrids is very important. In the world, hybrid tomatoes quickly dominated the seed market due to their quality and constant improvement.

The dry matter is a valuable indicator of fruit quality. The content of dry matter in tomato fruit varies depending on the variety or hybrid (DEMIR *et al*., 2008). Of all the phytochemicals present in tomatoes, the most significant is lycopene, a dominant carotenoid and one of the most powerful antioxidants in nature (AGARWAL and RAO, 2000). The tomato yields are dependant on variety, cultural practices, soils, and ecological limitations (ORTIZ *et al.*, 2007).

Consummation of tomatoes reduces the risk of chronic diseases such as cancer and cardiovascular diseases (RAIOLA *et al.*, 2014). The intake of tomato and its products is associated with the reduced risk of prostate, lung and stomach cancer (PALOZZA *et al.*, 2011). Due to the importance of vegetables in human nutrition, the recommended intake of tomato for adults is 400-500 g per day, and at an annual level from 25 to 32 kg (VISKELIS *et al*., 2005).

The aim of this study is to examine the dry matter content, lycopene in fruits and yield of Dutch tomato hybrids in the conditions of western Bosnia and Herzegovina.

MATERIAL AND METHODS

Plant material and field trial

The study was conducted on the experimental field of the Agricultural Institute of RS in Banja Luka on the location Lazarevo (Budžak) (latitude: 44°46'N, longitude: 17°11'E), on alluvial soil (Figure 1). The experiment was set up by a randomized block design in four repetitions during the three consecutive seasons (2011 to 2013) in a greenhouse without heating.

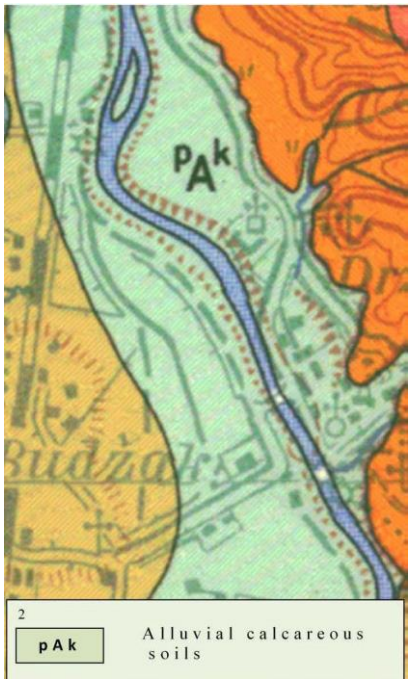

Figure 1. Pedological map of area Lazarevo (Budžak), Banja Luka, RS

Seven tomato hybrids were tested: Minaret F1, Rally F1, Torquay F1, Belle F1, Mondial F1, Monroe F1 and Berberana F1. Hybrid Minaret is the most widely used hybrid in tomato production in conditions of western Bosnia and Herzegovina, and it was used as a standard. Before the planting of tomatoes NPK fertilizer was applied to soil in the amount of 200 kg/ha, after which the tomato was regulary fed with water-soluble fertilizer Ferticare in the amount of 1 g per plant.

There were seven rows in the experimental plot, and each row represented a new hybrid. Sowing for the production of seedlings was done in containers in the second decade of February. Seedlings were seeded at the distance of 70 cm between rowsand 50 cm in a row. For the irrigation we used a drip system. Black PE foil was used for soil mulching. The harvest was done in technological maturity, successively, and the average fruit mass and yield were examined after all harvests. The entire production took place in a greenhouse without heating (the last decade of April until the last decade of August).

Weather conditions

Weather data (air temperatures) were obtained from a meteorological station Banja Luka (Table 1). Temperatures during the spring and summer of 2011 to 2013 enabled the intensive plant growth and development. Maturation period passed under optimal environmental conditions.

Table 1. Mean daily temperatures during the vegetation of tomato (April to August 2011–2013 from Banja Luka meteorological stations)

Month	Mean monthly air temperature (°C)			Mean daily temperature maximum for the month (°C)			Mean daily temperature minimum for the month (°C)		
	Year								
	2011	2012	2013	2011	2012	2013	2011	2012	2013
April	13.0	12.7	13.4	20.7	19.8	19.9	2.4	-3.8	6.9
May	16.0	16.1	16.6	23.4	23.2	23.1	9.7	1.3	4.8
June	21.2	23.0	13.4	29.6	30.1	26.4	16.2	15.7	16.9
July	23.1	25.2	23.0	30.1	32.7	30.7	15.8	17.7	15.5
August	23.7	24.4	23.5	31.2	34.3	31.3	16.5	15.6	16.9

Soil data

Chemical analysis indicates that the soil pH is favorable for growing vegetable crops (Table 2). The greenhouse soil in the surface soil layer in which experiments were conducted is rich in humus (6.0%). Data on the nitrogen content indicates the good soil provision with this element.

Soil analysis

Humus content was determined by the colorimetric method, digesting the samples with 1N $K_2Cr_2O_7$ and concentrated H_2SO_4 **(**RESULOVIĆ, 2002). Active and substitution reactions of soil (pH in H_2O and 1MKCl) were determined electrometrically. Carbonate content ($CaCO_3$) in the soil was determined with the method of Scheibler. Nitrate and ammonia nitrogen contents were determined by the method of Brenner, extracting the mineral forms of nitrogen (NH_4^+ , NO_2 and NO_3^-) with 2MKCl in the ratio 1:10, followed by a double distillation process.

Chemical analysis

The dry matter content in tomatoes was set by the method consisting in determination of weight loss by drying samples on 105°C and it is expressed in humidity percent. The dry matter content is expressed by the formula % DM = 100 – humidity %.

Lycopene content was determined spectrophotometrically, after separation by column chromatography.

During harvesting the mass of 20 fruits from each replication, after each harvest, was measured to establish a total yield.

Statistical analysis

All data in the present study were subjected to analysis of variance (ANOVA). Standard statistical method was used for data processing during the experimental study and LSD test for determination of differences between individual treatments.

RESULTS AND DISCUSSION

Based on the results of agrochemical analysis in the greenhouse, it can be concluded that the soil is fertile and that it will provide optimal soil conditions for high yields of good quality (BOŠKOVIĆ-RAKOČEVIĆ and PAVLOVIĆ, 2007). The analyzed soil was medium calcareous.

Alluvial soil for its fertility and the proximity of water for irrigation, represents the soil of high fertility, especially for vegetable production (MANOJLOVIĆ et al., 2014). The results of the agrochemical analysis of the soil in the experimental plot are shown in Table 2.

Table 2. Soil characteristics of the experimental site

Soil type	Depth (cm)	pH/KCl	pH/H_2O	Humus (%)	$CaCO_3$ (%)	NO_3-N (mg/100g)	NH_4-N (mg/100g)
Fluvisol	0-30	7.3	7.6	6.0	5.12	8.02	2.26

The main quality indicator of tomato fruits is the dry matter content. In general, the dry matter content among all tested hybrids ranged from 5.15% to 9.33% (Table 3). The obtained results indicate that tested hybrids represent an excellent starting point for quality increase of tomato fruits. In all tested hybrids the percentage of dry matter was over 5%. The highest three-year average dry matter content was recorded in hybrid Rally (8.14%), which is 33.9% higher than for the standard hybrid. For consumable tomato the dry matter content was 6.08% (PONJIČAN *et al*., 2012). Dry matter content of tomato hybrids was mainly considerably affected by growing season. With that in regard, average dry matter content was significantly lower due to temperature conditions.

Table 3. Year and hybrid effects on dry matter content in tested tomatoes

Impact of tomato hybrid (the factor B) and environment (weather conditions: the factor A: A1 = 2011, A2 = 2012, A3 = 2013) on dry matter content - DM (Banja Luka, Bosnia and Herzegovina)

Hybrid	DM (%)			
	A1	A2	A3	Mean B
Minaret	6.08	5.28	6.90	6.08
Rally	8.13	6.98	9.33	8.14
Torquay	6.15	5.73	6.68	6.19
Belle	5.53	5.15	6.13	5.60
Mondial	7.55	6.48	9.03	7.69
Monroe	5.48	5.25	6.98	5.90
Berberana	5.95	5.50	7.18	6.21
Mean A	6.41	5.77	7.46	
	A	B	A x B	
$P_{0.05}$	0.21	0.14	0.36	
$P_{0.01}$	0.28	0.18	0.48	

The highest dry matter content was determined in 2013 in all hybrids, and the lowest in the year 2012 of research. The total dry matter content in various tomato genotypes varied from 4.0% to 7.5% of fruits fresh weight (RADZEVIČIUS *et al*., 2016). In the three-year study the highest dry matter content was recorded in hybrid Rally compared to standard hybrid. Hybrid Berberana had the lowest dry matter content compared to standard hybrid. In the study of different tomato genotypes it has been shown that cherry tomato contains the highest level of dry matter

compared to other tomato hybrids (HALLMANN *et al.*, 2007). The dry matter content ranged from 6.64% to 9.06% in the organic tomato production, and in the conventional production from 6.37% to 8.44% (VISKELIS, 2015).

Measured mean values indicate that the lycopene content was significantly higher in 2013 in all hybrids (Table 4). The lowest lycopene content in all hybrids was registered in 2012. In a three-year study, the lowest average lycopene content was measured in hybrid Berberana (5.65 mg/100g) compared to standard hybrid. Content of lycopene in tomatoes ranged from 20.4 to 141 μg/g FW (GEORGE *et al.*, 2004).

Table 4. Year and hybrid effects on lycopene content in tested tomatoes

Impact of tomato hybrid (the factor B) and environment (weather conditions: the factor A: A1 = 2011, A2 = 2012, A3 = 2013) on lycopene content – LYC (Banja Luka, Bosnia and Herzegovina)

Hybrid	LYC (mg/100 g)			
	A1	A2	A3	Mean B
Minaret	6.65	5.45	7.30	6.47
Rally	8.25	6.58	9.53	8.12
Torquay	6.48	5.63	7.08	6.39
Belle	5.83	5.28	6.45	5.85
Mondial	7.18	6.28	7.68	7.04
Monroe	8.10	6.53	8.30	7.64
Berberana	5.58	5.13	6.25	5.65
Mean A	6.87	5.84	7.51	
	A	B	A x B	
$P_{0.05}$	0.15	0.10	0.27	
$P_{0.01}$	0.21	0.13	0.36	

The field grown tomatoes have been reported to contain higher levels of lycopene, ranging from 5.2 to 23.6 mg/100 g (TAKEOKA *et al.*, 2001), whereas, the green house grown tomatoes are reported to contain lycopene between 0.1 and 10.8 mg/100 g (LEONARDI *et al.*, 2000). HERNÁNDEZ-SUÁREZ *et al*. (2008) examined 39 different genotypes and determined significant variations in the lycopene content in fruits ranging from 0.6 to 6.4 mg/100g in a greenhouse, that is consistent with the results of this study. The reason for such a large variation of lycopene content in tomato fruits is certainly the genetic potential, but also the influence of abiotic factors, especially the temperature and light. According to studies of other the researchers it is evident that the lycopene content changes significantly and rapidly during maturation, mostly accumulated at full maturity of fruits. In order to avoid losses of lycopene content in fruits, it is recommended to pick fruits right before full maturity. Content of lycopene in tomato ranged from 3.9 to 7.7 mg/100g FW (SHAZAD, 2014) and from 0.14 to 14.4 mg/100g FW (MARUYANA, 2015) which is in accordance with the results of this research. The interaction of the year x hybrid indicates significant influence of temperature on lycopene content in tomatoes.

The results of the study show highly significant differences between the tested hybrids in terms of yield (Table 5). Significantly higher yield was achieved in all hybrids during the year 2013. Research results point out that the hybrid and year of research have had a major impact on the yield.

Table 5. Year and hybrid effects on tomato yield

Impact of tomato hybrid (the factor B) and environment (weather conditions: the factor A: A1 = 2011, A2 = 2012, A3 = 2013) on tomato yield (Banja Luka, Bosnia and Herzegovina)				
Hybrid	Yield (t/ha)			
	A1	A2	A3	Mean B
Minaret	48.90	43.16	50.85	47.64
Rally	71.03	61.26	75.14	69.14
Torquay	43.00	41.81	47.07	43.96
Belle	44.19	41.08	48.05	44.44
Mondial	60.10	57.66	63.60	60.45
Monroe	54.07	61.23	67.44	60.91
Berberana	69.39	65.97	71.81	69.06
Mean A	55.81	53.17	60.85	
	A	B	A x B	
$P_{0.05}$	0.80	0.52	1.38	
$P_{0.01}$	1.06	0.69	1.83	

The most productive hybrid Rally has achieved the highest yield (69.14 t/ha), while the lowest yield had the hybrid Torquay (Table 5). The bearers of yield are fruits from first two levels. Significantly higher tomato yield was obtained in 2013, which is characterized by the most favorable temperature for tomato growth and development. The tomato yield is conditioned by the genetic and environmental factors. In the three-year study the highest average yield was achieved by determinant hybrid Rally compared to the standard hybrid Minaret. The justifiably lowest average three-year yield had hybrid Torquay. Also, hybrid Belle did not have a significant impact on yield. All other hybrids showed a significant influence ($p<0.01$) of hybrid and year on tomato yield in comparison with the standard hybrid Minaret. Fruit yield per hectare ranged from 3.00 to 49.20 t/ha (CHERNET *et al.*, 2014). Differences in yield between hybrids are expected, for they are hybrids of different geographical origin. High tomato yields are the result of the joint action of hybrid genetic predisposition to high yield, applied technology and favorable agroecological conditions, which are the conclusions from previous research of a larger number of authors. The yield of different tomato hybrids ranged from 14.88 t/ha to 47.55 t/ha (BALCHA *et al.*, 2015) which is in accordance with the results of this research. The year as a component of the environment had a greater influence on the tomato yield than the hybrid. The interaction of the year x hybrid indicates a significant influence of the temperature on yield. In conclusion, the factors that had a decisive influence on the content of dry matter, lycopene content in fruit and tomato yield were year, hybrid effect and cultivation technology.

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OCENA HOLANDSKIH HIBRIDA PARADAJZA GAJENIH U USLOVIMA ZAPADNE BOSNE I HERCEGOVINE

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Izvod

Uporedna ocena izvršena je na sedam hibrida paradajza (*Lycopersicum esculentum* L.) u periodu 2011-2013 u plasteniku u Poljoprivrednom institutu Republike Srpske, Banja Luka, Bosna i Hercegovina. Cilj ove studije je ispitivanje sadržaja suve materije, likopena i ukupnog prinosa holandskih hibrida paradajza u uslovima zapadne Bosne i Hercegovine. Eksperiment je postavljen u randomiziranom blok sistemu u tri ponavljanja. Sadržaj suve materije se kretao od 5.60% do 8.14%. Hibrid i interakcija hibrid x godina imala je značajan uticaj na sadržaj likopena i prinos paradajza. U zaključku, faktori koji su imali odlučujući uticaj na sadržaj suve materije, sadržaj likopena u plodu i ukupni prinos paradajza bili su godina, hibrid i tehnologija gajenja.

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