

Morphological diversity of tomato accessions from the Gene Bank of the Republic of Srpska

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Abstract

In this research the aim was to determine differences in morphological characteristics between 11 tomato accessions from the Gene Bank of the Republic of Srpska. The experiment was conducted and analysis was performed during the 2018 and 2019 seasons. A total of 16 morphological characteristics (9 quantitative and 7 qualitative) were analyzed according to International Plant Genetic Resources Institute (IPGRI) descriptors for tomato. The results showed that polymorphism (diversity) was present in all quantitative characteristics and in 6 qualitative characteristics, while only one qualitative characteristic was monomorphic (no differences between accessions). Thereby, polymorphism was present in 93.75% of morphological characteristics. Out of a total of 9 quantitative characteristics, a highly significant difference ($p < 0.01$) was found in all characteristics except for the 1000-seed weight since this characteristic had only one value per accession measured according to the IPGRI tomato descriptors. The accessions from the Gene Bank of the Republic of Srpska have shown high diversity in all qualitative characteristics except in plant growth type, which was indeterminate in all analyzed accessions. This research provides a new insight into the research area of diversity of tomato landraces from the Republic of Srpska, which is important for further promotion and sustainable use of germplasm not only for scientific research purposes but also for national rural farmers, who are the key to preserving traditional knowledge and skills related to the cultivation and use of traditional varieties and tomato landraces.

Key words: germplasm, landrace, characterization, morphology, IPGRI descriptors

Introduction

The erosion of diversity of plant genetic resources used for human consumption significantly accelerated due to intensification and modernization of agricultural production (Adalid et al., 2010). One of the reasons for crops genetic vulnerability is the replacement of traditional landraces that have high genetic diversity by modern commercial varieties that have high genetic uniformity (Milošević and Nualsri, 2017). Compared to modern commercial varieties, tomato landraces have better taste, higher content of vitamin C, and other antioxidants (Mitchell et al., 2007). Recently, many producers have started using traditional cultivation methods and traditional locally recognizable varieties aiming to label their products as products with geographical indication of origin (Lazić et al., 2017). In certified organic vegetable production, the use of landraces is often recommended because of their better adaptation to local agro climatic conditions (Gonzalez-Cebrino et al., 2011). Sustainable use of landraces is also important for the conservation of traditional knowledge and skills of the particular area or region (Bocci et al., 2012).

It is estimated that there are over 75,000 tomato accessions maintained in genebanks worldwide (Robertson and Labate, 2007). The most numerous collections of Solanaceae species (excluding potato) are conserved in the Netherlands in the Botanical and Experimental Garden at the Radboud University (Bai and Lindhout, 2007). The Gene Bank of the Republic of Srpska was established in 2009 and its primary goal is *ex situ* conservation of plant genetic resources collected from territory of the Republic of Srpska. Its seed collection consists of a total of 1177 accessions of plant species, of which 45 accessions are tomatoes.

Many studies concerning characterization of tomato have been conducted worldwide (Villand et al., 1998; Mazzucato et al., 2008; Oğuz et al., 2014; Samad et al., 2017), which is a good indicator of its importance for both scientific research and tomato production. In Serbia, phenotypic and molecular characterization was done on 29 tomato genotypes belonging to the collection of the Institute of Field and Vegetable Crops in Novi Sad (Glogovac, 2016). Takač et al. (2005) and Glogovac and Takač (2010) state that the following old varieties and landraces of tomatoes have been preserved at the Institute of Field and Vegetable Crops in Novi Sad: volovsko srce, đevđelijski, tetovski, novosadski jabučar, novosadski rani, novosadski eksport, bitoljski rani, bitoljski kasni, čudorinska bela, skopski rani, etc. Čota et al. (2013) examined old Bosnian tomato variety – sarajevski jabučar. In the Republic of Srpska, until date Kukrić et al. (2016) studied landrace volovsko srce from the municipalities of Gradiška and Laktaši.

The aim of this research was to determine differences in morphological characteristics between different tomato accessions from the Gene Bank of the Republic of Srpska according to the IPGRI descriptors for tomato.

Material and methods

The research was conducted on 11 tomato accessions from the Gene Bank of the Republic of Srpska: GB00548 (amerikanac), GB00874 (amerikanac), GB01107 (paradajz), GB01110 (sitni paradajz), GB01123 (jabučar), GB01126 (trebinjski jabučar), GB01128 (jabučar), GB01129 (žuti paradajz), GB01132 (žuti amerikanac), GB01238 (žuti paradajz), and GB01239 (volovsko srce).

The field study was carried out in 2018 and 2019 (1 trial per season). Climate conditions for Banja Luka area during both trials are shown in Figure 1. According to the Republic Hydro-Meteorological Institute (<https://rhmzrs.com/>), May 2018 was the warmest ever recorded, May 2019 was cold with the highest precipitation ever recorded, while the rest of vegetation had average climate conditions for Banja Luka area.

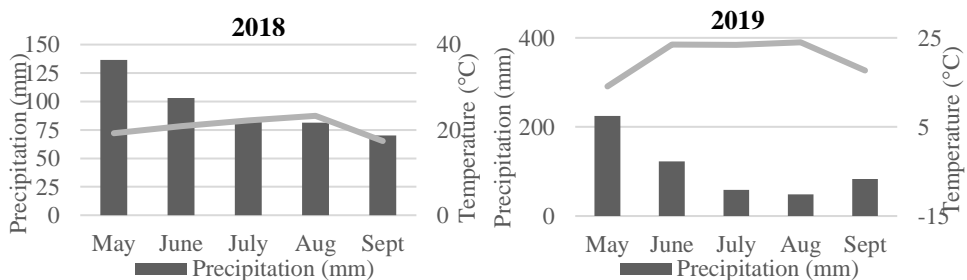


Fig. 1. Climate conditions for Banja Luka area during both trials, 2018 and 2019

For both trials, containerized seedlings were produced according to standard agricultural technology in the unheated glass greenhouse at the Faculty of Agriculture, University of Banja Luka. The experiment was established in a tunnel-type polypropylene greenhouse at the Institute of Genetic Resources, University of Banja Luka (158 m altitude, 44.774971 latitude and 17.211463 longitude) with the total area of 115 m². Fifty days after sprouting seedlings were planted in the soil at the facility, 10 plants per accession. The spacing between plants was 90 × 45 cm and a drip irrigation system was installed. Fertilization with organic and mineral fertilizers was applied before planting. Plants were maintained using standard horticultural practices such as trellising and pinching.

During vegetation, 16 morphological characteristics were analyzed according to the IPGRI morphological descriptors for tomatoes (1996), used for plant genetic resources. All the examined characteristics and their descriptions are summarized in Table 1. Plant and inflorescence characteristics were analyzed in the greenhouse, while fruit and seed characteristics were analyzed in the Laboratory of Pomology and Biotechnology of the Institute of Genetic Resources

when the fruits of the 2nd and 3rd truss have ripened. Fruit dimensions were measured with digital caliper (Unior 270A). The fruit and 1000-seed weight were measured on a technical scale (Kern PFB 1200-2). All obtained data was analyzed by standard descriptive statistical methods that included mean, minimum, maximum, standard deviation (SD), and coefficient of variation (CV). Level of statistical significance was determined at 0.01 probability level using the Fisher's F test (ANOVA) for all quantitative characteristics except for the 1000-seed weight since this characteristic had only one value per accession measured according to the IPGRI tomato descriptors.

Tab. 1. Morphological descriptors examined in this research (IPGRI, 1996)

Characteristic	Units	Scale
Plant growth type		1 Dwarf; 2 Determinate; 3 Semi-determinate; 4 Indeterminate
Vine length	cm	Measured on 10 randomly selected plants from the soil level to the tip of the longest stem of a plant
Leaf type		1 Dwarf; 2 Potato leaf type; 3 Standard; 4 Peruvianum; 5 Pimpinellifolium; 6 Hirsutum; 7 Other
Inflorescence type		1 Generally uniparous; 2 Both (partly uniparous, partly multiparous); 3 Generally multiparous
Presence of green trips on the fruit		0 Absent (uniform ripening); 1 Present (fruit shoulders - upper part of the fruit, around calyx - are green while pistilar area of the fruit is red)
Predominant fruit shape		1 Flattened (oblate); 2 Slightly flattened; 3 Rounded; 4 High rounded; 5 Heart-shaped; 6 Cylindrical (long oblong); 7 Pyriform; 8 Ellipsoid (plum-shaped); 9 Other
Fruit cross-sectional shape		1 Round; 2 Angular; 3 Irregular
Exterior color of mature fruit		1 Green; 2 Yellow; 3 Orange; 4 Pink; 5 Red; 6 Other
Fruit weight	g	Recorded on 10 randomly selected fruits
Fruit length	mm	Recorded on 10 randomly selected fruits from stem end to blossom end
Fruit width	mm	Recorded on 10 randomly selected fruits at the largest diameter of cross-sectioned fruits
Pedicle length	mm	Measured on 10 randomly selected fruits from peduncle to calyx
Thickness of pericarp	mm	Measured on 10 randomly selected fruits from an equatorial section
Size of core	mm	Measured on 10 cross-sectional randomly selected fruits at the widest part of the core
Number of locules	n	Counted on 10 randomly selected fruits
1000-seed weight	g	Weight of 1000 randomly selected mature air-dried seeds

Results and discussion

In this research, out of a total of 16 analyzed morphological characteristics (9 quantitative and 7 qualitative), polymorphism (diversity) was determined in all quantitative and in 6 qualitative characteristics. Only one qualitative characteristic – plant growth type was monomorphic (no differences between accessions) and all analyzed genotypes showed indeterminate growth. Thereby, polymorphism was present in 93.75% characteristics.

Standard descriptive statistics and statistical significance for 9 quantitative characteristics in the 11 tomato accessions for both trials are summarized in Table 2. Out of total of 9 quantitative characteristics, highly significant difference ($p < 0.01$) was found in all characteristics except for the 1000-seed weight. This characteristic had only one value per accession measured according to the IPGRI tomato descriptors. Regardless of the trial, the highest coefficient of variation (CV) was calculated for fruit weight (55.4 and 53.4), followed by number of locules (51.1 and 46.3) and size of core (34.1 and 39.5), while the lowest coefficient of variation was calculated for 1000-seed weight (14.3 and 11.8), followed by vine length (12.2 and 19.7), and pedicel length (16.2 and 17.6).

Vine length of analyzed accessions ranged from 65.8 to 207.5 cm, which is in accordance with the research of Agarwal et al. (2014), where vine length ranged from 72 to 213.33 cm in 31 accessions analyzed at the Defence Institute of Bio-Energy Research in India. Fruit weight ranged from 16.9 to 202.6 g, which is in line with Al-Aysh et al. (2012), where fruit weight ranged from 9.41 to 185.33 g. Fruit length of analyzed accessions ranged from 35.8 to 67.9 mm, which is similar to the research of the Institute of Field and Vegetable Crops in Novi Sad where fruit length ranged from 38 to 63 mm in 29 analyzed tomato genotypes (Glogovac, 2016). Fruit width ranged from 31.6 to 76.7 mm, which is in accordance with Salim et al. (2020), where fruit width ranged from 36.3 to 81.5 mm. Figàs et al. (2015) reported pedicel length in the range of 20.9 to 55 mm, which is similar to our results, where pedicel length ranged from 22.3 to 37.1 mm. Thickness of pericarp of the analyzed accessions ranged from 3.2 to 6.7 mm, which is similar to Glogovac (2016), where thickness of pericarp ranged from 3.6 to 7.8 mm. The size of core ranged from 9 to 36.9 mm, which is in accordance with the research of Figàs et al. (2015), who obtained values of the size of core in the range of 8.3 to 51.3 mm. Number of locules ranged from 2 to 9.6, which is in line with the research of Glogovac and Takač (2010), in which number of locules ranged from 2 to 10.2 in 19 landraces and old tomato varieties from the Institute of Field and Vegetable Crops in Novi Sad. In this study, the 1000-seed weight ranged from 2.43 to 3.87 g, which is similar to Đurovka (2009), where it ranged from 2.8 – 4 g.

Tab. 2. Standard descriptive statistics and statistical significance for 9 quantitative characteristics in the 11 tomato accessions for both trials, 2018 and 2019

Quantitative characteristics	Units	Research year	Min – Max	Mean \pm SD	CV (%)	F value
Vine length	cm	2018	138.3 – 207.5	159.2 \pm 19.5	12.2	9.92**
		2019	65.8 – 136.7	108.9 \pm 21.5	19.7	10.46**
Fruit weight	g	2018	16.9 – 202.6	98.2 \pm 54.4	55.4	10.13**
		2019	22.0 – 167.7	81.0 \pm 43.3	53.4	11.22**
Fruit length	mm	2018	35.8 – 67.9	51.5 \pm 9.7	18.7	22.43**
		2019	37.1 – 65.0	46.3 \pm 8.8	19.0	15.82**
Fruit width	mm	2018	33.7 – 76.7	56.6 \pm 13.2	23.3	17.48**
		2019	31.6 – 74.8	53.9 \pm 13.2	24.5	17.88**
Pedicel length	mm	2018	22.3 – 37.1	28.7 \pm 4.7	16.2	5.58 **
		2019	22.9 – 35.0	29.5 \pm 5.2	17.6	6.06**
Thickness of pericarp	mm	2018	3.2 – 6.7	5.1 \pm 1.1	22.0	9.19**
		2019	3.9 – 6.5	4.9 \pm 0.8	17.1	8.03**
Size of core	mm	2018	10.7 – 31.5	21.3 \pm 7.3	34.1	15.04**
		2019	9.0 – 36.9	23.3 \pm 9.2	39.5	17.19**
Number of locules	n	2018	2.0 – 9.6	5.0 \pm 2.5	51.1	16.85**
		2019	2.0 – 8.9	5.3 \pm 2.5	46.3	21.79**
1000-seed weight	g	2018	2.4 – 3.9	2.9 \pm 0.4	14.3	
		2019	2.6 – 3.7	3.0 \pm 0.3	11.8	

** = significant at 0.01 probability level ($F_{(0.01)} = 2.505$)

Frequency distribution of 11 tomato accessions for 7 qualitative characteristics in both trials is summarized in Figure 2. Accessions from the Gene Bank of the Republic of Srpska have shown high diversity in all qualitative characteristics except in plant growth type, which was indeterminate in all analyzed accessions. All observed accessions had a standard tomato leaf type, except accession GB00874, which had potato leaf type. Uniparous inflorescences were observed in five accessions in both trials. Multiparous inflorescences were observed in three accessions in both trials and in two accessions in 2019. Both types of inflorescences were observed in one accession in both trials and in two accessions in 2018. Presence of green trips on the fruit was determined in two accessions in both trials and in one accession in 2019. Absence of green trips on the fruit was determined in four accessions in both trials and in one accession in 2019. Other accessions had part of the fruits with and other part of the fruits without the green trips. Predominant fruit shape was flattened in two accessions, slightly flattened in three accessions, rounded in three accessions, high rounded in two accessions and heart-shaped in one accession. Fruit cross-sectional shape was round in four accessions, irregular in one accession in both trials and in two accessions in 2019 only, while other accessions had part of the fruits with round and other part of the fruits with irregular cross-sectional shape. Regardless of the trial, most of the observed accessions had red exterior colour of mature fruit, while three accessions had yellow and one accession had pink exterior colour of mature fruit.

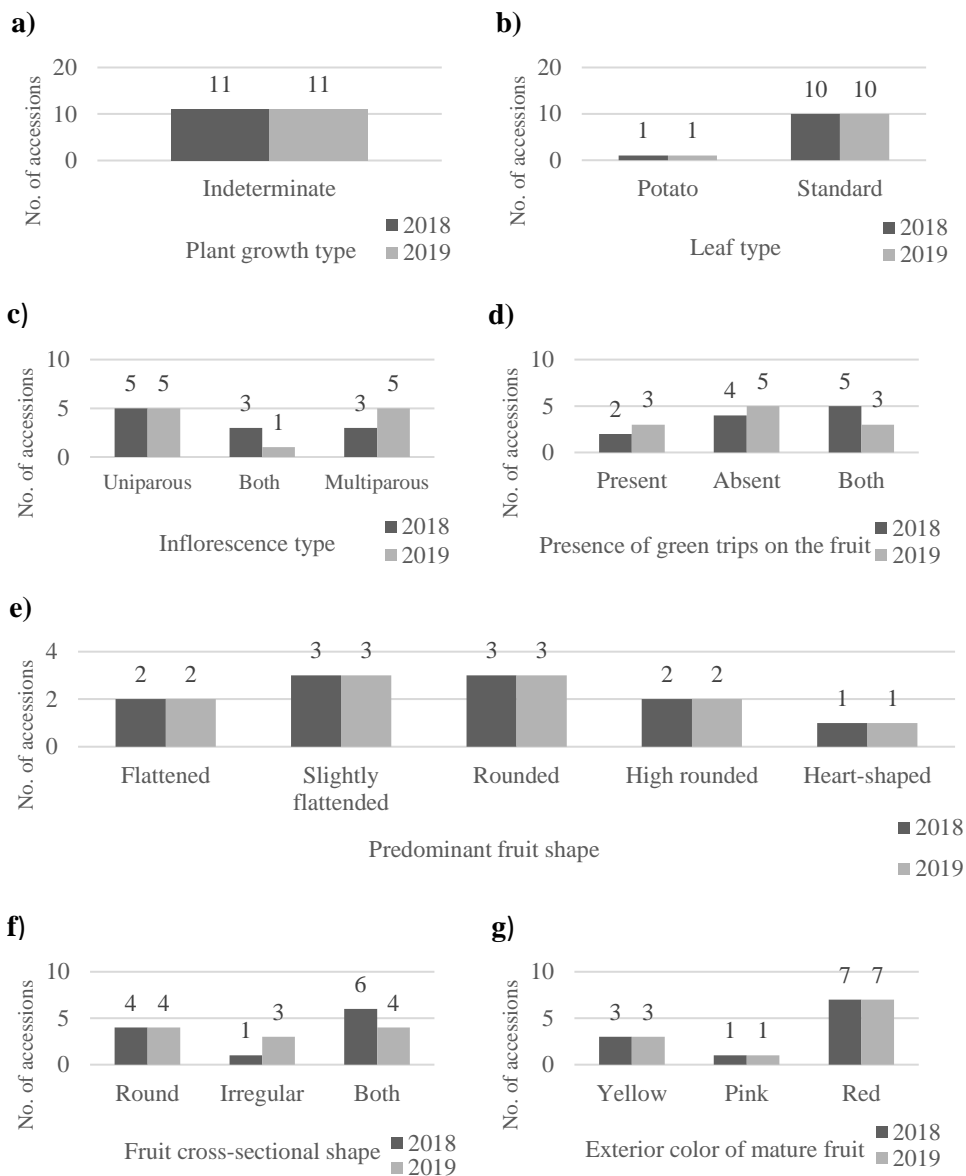


Fig. 2. Frequency distribution of 11 tomato accessions for 7 qualitative characteristics in both trials: a) plant growth type, b) leaf type, c) inflorescence type, d) presence of green trips on the fruit, e) predominant fruit shape, f) fruit cross-sectional shape and g) exterior colour of mature fruit

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Conclusion

In this research polymorphism is present in 93.75% characteristics, which proves that accessions from Gene Bank of Republic of Srpska have high genetic diversity. This research provides new insight into the research area of diversity of tomato landraces from the Republic of Srpska, which is important for further promotion and sustainable use of germplasm not only for scientific research purposes but also for rural farmers in the Republic of Srpska, who are of utmost importance to preserving traditional knowledge and skills related to the cultivation and use of traditional varieties and tomato landraces. A proposal for further research with the analyzed accessions would be their molecular characterization in order to possibly use them in future breeding programs.

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Морфолошка разноврсност принова парадајза из Банке гена Републике Српске

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Сажетак

У овом истраживању циљ је био утврдити разлике у морфолошким карактеристикама између 11 принова парадајза из Банке гена Републике Српске. Оглед је постављен и анализе су вршене током 2018. и 2019. године. Праћено је укупно 16 морфолошких карактеристика (9 квантитативних и 7 квалитативних) према IPGRI дескрипторима за парадајз. Резултати су показали да је код свих квантитативних и код 6 квалитативних карактеристика утврђена полиморфност (разноврсност), док је само 1 квалитативна карактеристика била мономорфна (између принова није било разлика). Утврђен је полиморфизам код 93,75% морфолошких карактеристика. Од укупно 9 квантитативних карактеристика високо значајна разлика ($p < 0.01$) је утврђена код свих карактеристика осим код масе 1000 сјеменки јер за ову особину, а у складу са IPGRI дескрипторима, није рађено одређивање нивоа значајности. Принове из Банке гена Републике Српске су показале високу разноврсност код свих квалитативних карактеристика осим код типа раста биљке, који је био индетерминантан код свих анализираних принова. Овим истраживањем је добијен нови увид у истраживачку област разноликости локалних популација парадајза са подручја Републике Српске, што је значајно за даљу промоцију и одрживо коришћење гермплазме не само за научноистраживачке сврхе него и за сеоска домаћинства у Републици Српској која су кључна за очување традиционалних знања и вјештина везаних за гајење и коришћење традиционалних варијетета и локалних популација парадајза.

Кључне ријечи: гермплазма, локална популација, карактеризација, морфологија, IPGRI дескриптори

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