STUDIES ON THE MORPHOBIOLOGICAL CHARACTERISTICS, PRODUCTIVITY AND RESISTANCE TO HIGH TEMPERATURES AT TOMATOES

STUDII PRIVIND CARACTERELE MORFOBIOLOGICE, PRODUCTIVITATEA ŞI REZISTENŢA LA TEMPERATURI ÎNALTE LA TOMATE

MIHNEA Nadejda[1*], LUPAŞCU Galina[1], VÎNATORU C.[2*], CRISTEA N.[1]
*Corresponding author e-mail: mihneanadea@yahoo.com, costel_vinatoru@yahoo.com

Abstract. *The paper presents the results of the appreciation of varieties and lines from the collection of tomatoes of the Institute of Genetics, Plant Physiology and Plant Protection, Republic of Moldova based on productivity, resistance to stressing temperatures and some fruit characters. The analysis of the useful characters of the studied forms from the collection revealed a wide variability in the fruit characters, the overall productivity, the share of the fruits, which allows selection and recommendation of the most valuable forms for hybridization and obtaining new varieties and hybrids of different destination. Cluster analysis (k-means method) demonstrated that the 38°C temperature level manifested a higher discriminative capacity of tomato clusters based on root and strain length (controlled conditions), which revealed the more pronounced interaction specificity with this temperature level. Were identified clusters of tomato genotypes with diminished reaction at stressful temperatures, which is important for the involvement in programs to improve genotypes with increased resistance to heat.*
Key words: tomato, variability, fruit characters, productivity, strength, stressful temperatures

Rezumat. *În lucrare sunt prezentate rezultatele aprecierii unor soiuri şi linii din colecţia tomatelor de cultură ale Institutului de Genetică, Fiziologie şi Protecţie a Plantelor, Republica Moldova în baza productivităţii, rezistenţei la temperaturi stresante şi unor caractere ale fructului. Analiza caracterelor utile ale formelor studiate din colecţie a evidenţiat o variabilitate largă privind caracterele fructului, productivitatea generală, cota fructelor marfă, ceea ce permite selectarea şi recomandarea celor mai valoroase forme pentru hibridare şi obţinere a soiurilor şi hibrizilor noi cu diferită destinaţie. Analiza clusteriană (metoda k-mediilor) a demonstrat că nivelul de temperatură de 38^0C, a manifestat o capacitate discriminantă mai înaltă a clusterelor de tomate în baza caracterelor lungimea rădăciniţei şi tulpiniţei (condiţii controlate), ceea ce relevă specificitatea mai pronunţată de interacţiune cu acest nivel de temperatură. Au fost identificate clustere de genotipuri de tomate cu reacţie diminuată la temperaturi stresante, ceea ce are importanţă pentru implicarea în programele de ameliorare a genotipurilor cu rezistenţă sporită la arşiţă.*
Cuvinte-cheie: tomate, variabilitate, caractere ale fructului, productivitate, rezistenţă, temperaturi stresante

[1]Institute of Genetics, Physiology and Plant Protection, Republic of Moldova
[2]Vegetable Research and Development Station Buzău, Romania

INTRODUCTION

The morphobiological characteristics of tomato fruit are determined by several genes that interacting with environmental factors at different stages of plant growth, provide a strong variability of character (Lippman and Tanksley, 2001). Consumers' predilections for size, aesthetic aspect of the fruit, and the need for certain pericarpic particularities related to transportability, make the actual interest of the breeders more attractive for their variability for practical use.

More and more frequent environmental imbalances in recent decades lead to considerable decreases in productivity and quality of agricultural production including tomatoes. In this connection, research has been intensified in the field of plant resistance to unfavorable biotic and abiotic factors (Hazra *et al.,* 2007; Mihnea *et al*., 2013; Mihnea *et al*., 2015; Mihnea, 2016; Lupascu *et al.,* 2017).

Higher than optimal temperatures can cause physiological disturbances in tomato plants, leading to a decrease in the vegetation period, accelerating the flowering and baking of fruits (Ansary, 2006), or to the nonuniform passage of these processes (Adams and Valdes, 2002; Mulholland *et al.,* 2003).

At temperatures higher than 35°C, germination, flowering, meiosis development, large fruit formation, egg development and viability, as well as embryo development (Wahid *et al.,* 2007) are affected by most varieties of tomatoes. Under stressful conditions, resistant tomato genotypes have the ability to form a much larger number of fruits than the sensitive ones (Comlekcioglu *et al.*, 2010). This situation requires the creation of tomato genotypes with resistance to extreme environmental factors (Venema *et al*., 2005; Hazra *et al.,* 2007; Mihnea *et al.*, 2016).

An important role has the tomato fruit properties. The main characteristics of the tomato fruit are: the mass, the fruit index (the ratio of the length to the fruit diameter), the thickness of the pericarp, the thickness of the mesocarp, the locule number. Knowing the degree of their variability allows for more efficient use of the original material in breeding research (Mihnea, 2012).

The purpose of the research was to study the phenotypic variability of some important quantitative characters in tomatoes and the lability of some perspective genotypes at stressful temperatures for their inclusion in the breeding process.

MATERIAL AND METHODS

As research material, they served 12 varieties and 6 lines of different origins. The lines and varieties Kristina, Florina, Măriuca, Darsirius and Buzău 47 are of Romanian origin and were kindly offered by Dr. Costel Vinatoru from the Buzau Research and Development Station for Vegetables. The experiments were performed in laboratory and field conditions on the experimental field of the Institute of Genetics, Plant Physiology and Plant Protection, Republic of Moldova.

Testing of the high temperature genotype reaction was performed according to the method proposed by Ivakin (1979), based on the growth capacity of the plants after keeping them at high temperatures for 6 hours. High temperature temperatures of 35ºC, 38ºC and 42ºC were used to analyze the influence of high temperatures on the embryonic root and stem.

Tomatoes were grown by seedling culture in three repetitions by standard method (Ersova, 1978). Sowing in the greenhouse took place in the third decade of March, planting in the field in the second decade of May. Under field conditions the morphological description was performed according to the UPOV descriptor (2011). The data obtained were statistically processed in the STATISTICA 7 software package.

RESULTS AND DISCUSSIONS

The data obtained showed essential differences of genotypes according to the average fruit weight. There were 7 large fruit shapes: Santa Maria, Pontina, Kristina, Florina, L 11, L 66, L 713. The character variation range was 10.2-35.5 g, and the coefficient of variation in the analyzed tomato group was 22.0%, indicating the rather pronounced variability of character. Forms evaluated based on the thickness of pericarp were very different, the index ranging from 3.3 ... 9.5 mm (fig. 1). The calculation of the coefficient of variation showed a significant variability of the assessed character – 23.8%.

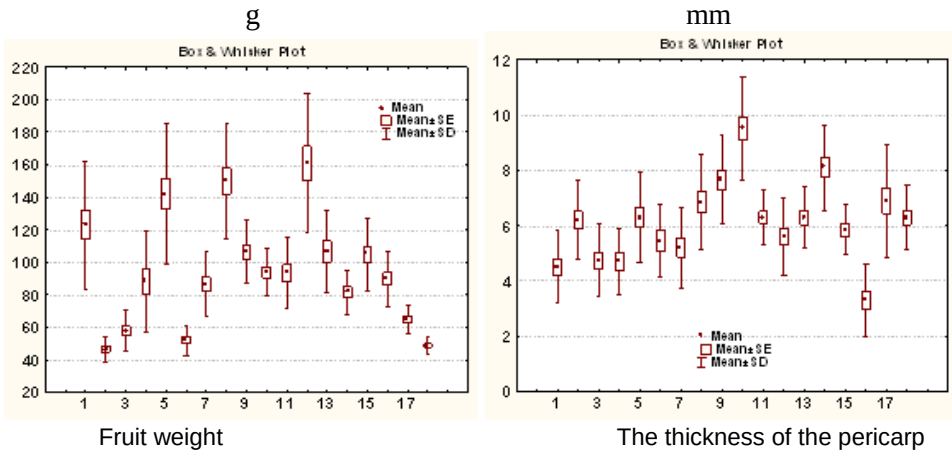


Fig. 1 Morphobiological characters of tomato fruit
1 – Santa Maria, 2 – Roma, 3 – Luci, 4 – Alex, 5 - Pontina, 6 – Flacăra, 7 – Kristina, 8 – Florina, 9 – Măriuca, 10 – Darsirius, 11 – L 10, 12 – 11, 13 – L 66, 14 – L 71(România), 15 – L 713, 16 – L 714, 17 – Buzău 47, 18 – Marglobe

In our researches, there was an insignificant variability of the length and width of the fruit to the studied forms (4.0 ... 10.8% and 3.8 ... 14.3%, respectively). Most forms had a coefficient of variation not exceeding 10% (tab. 1). The average variability of the samples tested was 7.4% for the fruit length and 9.4% for the fruit width, which allows the characters to be characterized as having low heterogeneity.

The data showed a wide range of mesocarp thickness variability in the analyzed samples: V = 9.5-24.3%, the average of the parameter constituting 15.3%, which shows an average variability of the study group according to the analyzed character.

The study of the locule number in the fruit showed that for most varieties it was 2-3, 5-8, with regular settlement, and the average coefficient of variation was 19.2%.

Table 1

Phenotypic variability of some tomato fruit characters

Variety, lines	Length of fruit mm		Fruit diameter mm		Mesocarp thickness mm		Number of locule number	
	$x \pm m_x$, g	V,%	$x \pm m_x$, mm	V,%	$x \pm m_x$, mm	V,%	$x \pm m_x$, mm	V,%
Santa Maria, control	50.1±4.2	8.4	67.4±2.2	14.3	50.1±1.9	16.7	5.6±0.3	22.0
Roma	45.5±0.6	6.3	43.1±0.8	7.9	27.2±1.1	18.5	2.1±0.1	14.7
Luci	66.6±1.6	10.8	39.2±0,6	7.0	25.5±0.8	13.5	2.9±0.1	17.2
Alex	69.1±1.5	8.6	48.5±2.1	17.3	36.0±2.4	24.3	3.2±0.2	17.6
Pontin	58.9±1.0	7.7	65.6±1.7	11.6	55.5±3.7	22.1	4.2±0.2	21.3
Flacăra	44.4±0.7	6.9	44.7±0.7	7.0	63.1±1.5	10.9	2.6±0.1	23.0
Kristina	50.9±1.0	7.5	56.5±1.2	9.3	41.4±1.0	10.4	3.0±0.1	13.4
Florina	62.6±1.2	8.6	69.7±1.4	8.8	53.0±1.5	12.3	4.4±0.2	20.1
Măriuca	65.0±1.2	8.2	56.9±1.0	8.2	36.9±1.3	16.0	3.1±0.1	16.7
Darsirius	68.9±1.4	9.0	52.1±0.9	7.3	27.5±1.1	18.1	2.3±0.1	24.8
L 10B	51.8±1.1	9.3	55.6±1.5	12.1	41.2±1.5	16.0	2.8±0.1	18.7
L 11	59.5±0.9	6.6	70.4±1.9	12.2	52.2±1.8	15.4	4.9±0.2	18.0
L 66	54.2±0.8	5.8	60.7±1.6	10.9	47.2±1.1	9.5	3.1±0.2	22.3
L 71	56.7±1.0	7.6	51.8±0.6	5.4	32.8±0.9	12.8	2.1±0.1	14.7
L 713	45.0±0.6	6.3	62.8±1.3	9.3	50.7±1.8	12.4	4.3±0.2	17.4
L 714	46.4±0.7	6.1	61.3±1.5	10.1	50.9±1.6	12.4	6.4±0.3	21,2
Buzău 47	53.2±0.6	5.1	48.5±0.8	7.3	29.7±1.0	14.4	2.3±0.1	24.8
Marglobe	44.4±0.4	4.0	43.9±0.4	3.8	27.9±1.2	19.9	2.2±0.1	17.0
Mean:		7.4		9.4		15.3		19.2

Testing of tomato varieties has made it possible to elucidate a significant productivity variability that depends both on genotype and climatic conditions. The productivity of varieties studied in 2018 varied between 22.0 t / ha (Luci) and 78.6 t / ha (Măriuca) (fig. 2). An increased productivity compared to the control variety, the total harvest of which was 32.9 t /ha, was recorded in the genotypes Măriuca (78.6 t / ha), Flacăra (63.4 t / ha), L 66 (61 , 4 t / ha), Florina (59.7 t / ha), L 11 (59.4 t / ha), Darsirius (56.0 t / ha) L 71 (50.6 t / ha). The harvest of varieties in the studied varieties proved to be quite high and ranged from 34.3% (Marglobe) to 90.4% (Darsirius).

Subsequently, varieties and lines that exhibited a complex of valuable characters were tested under laboratory conditions to determine the reaction of juvenile plants to stressful temperatures.

As a result of the appreciation of tomato genotypes based on the resistance of the embryonic root and the stem, the resistance to high temperatures of the plantlets varies widely and depends both on the genotype and on the temperature level (tab. 2).

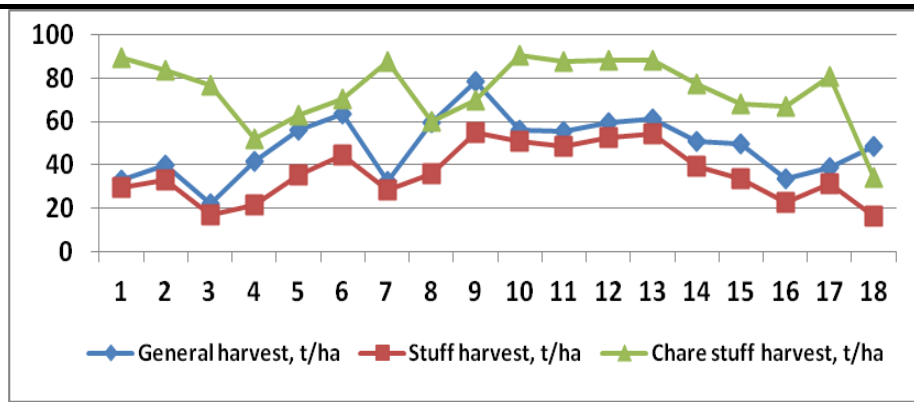


Fig. 2 The characteristic of growing tomato forms based on productivity
1– Santa Maria, 2 – Roma,3 – Luci, 4 – Alex, 5 – Pontina (Dacia), 6 – Flacăra, 7 – Kristina, 8 – Florina, 9 – Măriuca, 10 – Darsirius, 11 – L 10B, 12 – L11, 13 – L 66, 14 – L 71,15 – L 15, 16 – L 714, 17 – Buzău 47, 18 – Marglobe

Table 2

Variability of resistance to high temperatures in tomatoes

Variety, line	Resistance,%					
	Based on the embryonic root length			Based on stem length		
	35^0C	38^0C	42^0C	35^0C	38^0C	42^0C
Roma	80.0	108.6	71.8	75.9	62.7	64.1
Pontina	101.9	71.7	54.2	119.7	74.5	82.9
Flacara	90.7	85.8	48.1	101.1	83.5	92.2
Florina	81.8	64.5	48.8	57.6	70.7	52.3
Mariuca	85.7	89.3	44.6	67.7	89.0	45.4
L 10B	102.2	107.7	81.5	74.0	54.4	64.1
L 11	79.4	70.0	57.2	67.5	37.8	93.0
L 66	89.9	96.6	52.8	55.8	57.0	44.5
L 71	103.4	103.4	76.5	89.6	92.5	103.5
Mary Gratefully	81.9	77.2	63.9	90.0	72.2	68.0

The genotypes showed increased resistance of the embryonic root at 35 and 38ºC except Florina, with an average resistance (64.5%).

Increased resistance to 42ºC was manifested by Mary Gratefully (63.9%), Rome (71.8%) and L 71 (76.5%), L 10B (81.5%). The strain resistance variability was higher and ranged from 37.8 to 119.7%. Of particular interest for the further improvement are the genotypes Mary Gratefully and L 71 which show resistance of both characters.

As can be seen from the data presented (Figure 3A), the influence of stressful temperatures on the growth of the embryonic root in the tomato genotypes included in the study is different. In the case of the thermal regime of 35 ° C the values of character in optimal conditions ranged from 37.3 ... 62.2 mm,

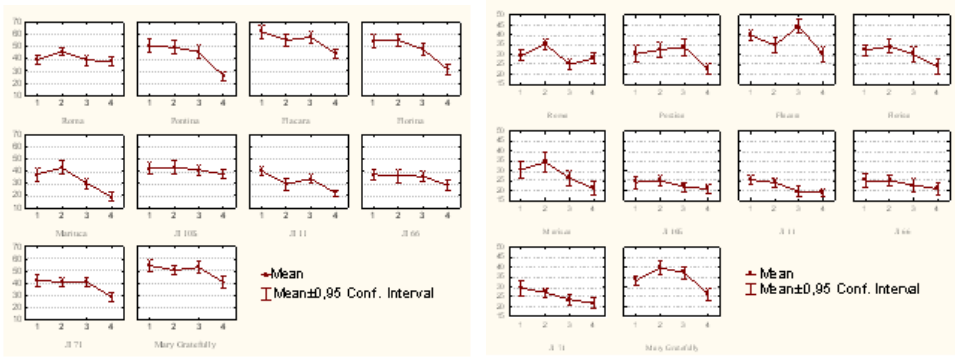
and in stressful conditions – 29.4 ... 51.3 mm. In Pontina, Mary Gratefully, Flame, L 71, L 66 and L 11, the diminution of character showed values of -3.1; -6.8; -11.7; -1.9; -3.2; -27.1% - compared with the witness.

In the case of the thermal regime of 38°C, the decrease of the length of the root has registered values of 2.6 ... 19.3%. There was 13.9% stimulation with Măriuca variety and insignificant inhibition – Mary Gratefully and L 10B, L 66, L 71 lines. Under the action of 42ºC temperature, embryonic root growth was suppressed in most of the analyzed forms. The level of diminution of character showed values of -0.5 (Rome); -12.8 (L 10B); -24.1 (L 66); -25.3 (Mary Gratefully); -29.2 (Flame); -31.1 (L 71); -42.8 (Florina); -45.2 (L 11); -48.9 (Măriuca); -49.3% (Pontina). As a result of the genotype appreciation according to the resistance of the root, Roma variety and L 10B high resistance line were selected, and Mary Gratefully varieties, flame and L 66, L 71 resistant lines.

The stem length of the analyzed genotypes ranged from 24.3 ... 39.7 mm (fig. 3B). Under the influence of high temperatures, there was a quite different reaction and variability: in 19 cases inhibition occurred (-5.5%, ... -31.1%) and in 11 – stimulation of the stem (+ 3.3%. .. + 32.2%). The strong inhibition under the influence of the temperature of 38ºC was attested in Marici (-28.4%) and L 11 (-22.8%); (-25.0%), Florina (-25.8%), Mariuka (-31.1%), L 11 (-25.6), L 71 (-26.5%); growth stimulation was recorded at 7 genotypes at 35ºC, three at 38ºC and at a genotype at 42ºC. It is worth mentioning that the varieties Rome, Mary Gratefully and the L 10B, L 66 lines showed resistance of both characters, so they are of interest for improvement as possible donors of resistance to heat.

The processing of the experimental data by bifactorial analysis of the variance allowed the appreciation of variability and degree of influence of temperature, genotype and their interaction on the variability of the evaluated characters.

mm



A B

Fig. 3 Influence of stressful temperatures on the growth of tomato root embryo (A) and on the growth of tomato strain (B);
Vertically: the length, mm; Horizontally: 1- 25^{0}C; 2 – 35^{0}C; 3 – 38^{0}C; 42^{0}C.

It was found that the contribution of genotype, temperature, and genotype x temperature interaction to the growth of tomato embryonic roots was 33.7; 63.1; 2.5%, and for stem growth – 44.8; 50.2; 4.0% respectively (tab. 3). So the temperature (63.1 and 50.2%) has a major influence on the growth of the embryonic root and the stem. It is worth mentioning that in the case of the strain the role of the genotype increased by 11.1%.

Table 3

Factorial analysis of tomato *genotype x high temperature* relations

Source of variation	Freedom degree	Average square sum	Contribution to source of variation,%
Root length			
Genotype	9	12182*	33.7
Temperature	3	22806*	63.1
Genotype x temperature interaction	27	892*	2.5
Random effects		266	0.7
Stem length			
Genotype	9	5363*	44.8
Temperature	3	6011*	50.2
Genotype x temperature interaction	27	483*	4.0
Random effects	579	126	1.0

*- p≤0.05.

CONCLUSIONS

1. The analysis of the useful characters of the studied forms in the collection revealed a wide variability in the fruit characters, the overall productivity, the share of the f*ruit, etc., which allows selection and recommendation of the most valuable forms for hybridization and obtaining* of new varieties and hybrids with different destination.

2. As a result of the analysis of the reaction of varieties and tomato lines at different stress levels (35°C, 38°C, 42°C) based on the stem and embryonic root lengths it was found that temperatures of 35ºC and 38ºC in most cases did not significantly influence the growth of the roots. Significant repression was recorded only at the line L 11 (-27.1) under the influence of the temperature of 35ºC and at L 310 (-15.0%) under the influence of the temperature of 38ºC. Growth of the root at the evaluated lines was most strongly influenced by temperature 42ºC, mean values relative to the control ranging from -0.5 ... -45.2%.

3. By bifactorial analysis of variance, it was found that for both the embryonic root and the tomato strain, the major contribution to the character variation source had the temperature (63.1 and 50.2%, respectively). It should be noted that an imported role he had the genotype, its factor weight constituted 33.7% for the embryonic root and 44.8% for the stem, which shows the high

opportunity for improvement of the character by identifying genotypes that do not show a pronounced sensitivity at high temperature (35 ... 42°C).

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