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THE ROLE OF THE PARENTAL FACTOR IN THE MANIFESTATION OF GROWTH AND DEVELOPMENT TRAITS AT THE F_1 TOMATO HYBRIDS

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Abstract

The paper presents the results of assessing the resistance of some parent varieties and reciprocal F_1 combinations of tomatoes to stressful (40°, 42ºC) and optimal (25ºC) temperatures. The analysis of the variability of the resistance character was carried out based on the length of the embryonic radicle, stem and whole seedling. In most of the cases stressful temperatures produced significant inhibition of growth organs. The differences in the manifestation of the analyzed characters in the reciprocal F_1 hybrids both in the control variant and in the variants with stressful temperatures demonstrate the involvement of the parental factor in their phenotype on the background of different temperatures. The maternal effect was more pronounced at the temperature of 42ºC than under optimal conditions. Manifesting of the parental entity effect on the degree and orientation of dominance reveals its influence on the allelic interactions of the F_1 heterozygous genotype. The overdominance in relation to the best parent indicates that the parental entity intensifies the influence of the recessive alleles on those dominant, involved in the control of growth characters of tomato plants.

Key words: *tomato, temperature, variability, parental effect, dominance.*

INTRODUCTION

Climate change most directly influences the productivity and quality of fruits, and thermal stress is a major abiotic factor that worldwide limits the productivity of crops, including tomatoes, thus presenting a problem for food security (Battisti, 2009; Asseng et al., 2011; Bita & Gerats, 2013; Tripathi et al., 2016; Bisbis et al., 2018). Although the extent of climate changes cannot be exactly predicted, the prognosis of the specialists in the field take into account that we can expect a higher frequency of extreme weather events, with the associated risks and damages becoming more significant (Van & Darriet, 2016).

Based on several scenarios, by the end of the 21st century global temperatures are expected to increase by an average of 1-3.7ºC above their 1986-2005 levels (IPPC, 2014). The challenges generated by climate change will thus require the implementation of appropriate and cost-effective strategies to adapt newly created varieties in a timely manner to local conditions for an effective risk reduction (Fraga et al., 2012; Porter et al., 2014; Bisbis et al., 2018).

Although tomatoes are grown in different ecological and geographical areas, they are particularly sensitive to high temperatures. The optimum temperature for tomato cultivation is 25-30°C during the day and 20ºC at night (Camej et al., 2005; Ribeiro et al., 2008; Carvalho et al., 2011).

The increase of a few degrees from the optimal temperature can greatly affect the reproductive organs, especially the viability of pollen, the development of gametes and the pollination capacity, as a consequence the productivity decreases considerably (Peet et al., 1997; Sato et al., 2000; Firon at al., 2006). High temperatures can cause significant productivity losses and damage to fruit quality (Nahar & Ullah, 2011). The wide spread of highly productive tomato varieties created in the Republic of Moldova is affected by the increasingly fluctuating biotic and abiotic conditions, specific to this area in recent decades.

The incorporation of genetic resistance in crop plants is considered the most effective and sustainable method of reducing the effects of limiting conditions. For the intended purpose, it is necessary to know the genetic basis of the reaction to adverse factors. It should be noted that due to its quantitative nature, resistance depends on a series of factors, among which we

can mention genotypic, environmental factors and *genotype x environment* interactions.

The complex genetic determinism of quantitative characters, including resistance to heat, makes it difficult to succeed in the breeding activity, whose goal is to create genotypes that combine several valuable characters. It is known that quantitative traits are more easily improved in the case of their high heritability, and their genetic variability is important for expanding the genetic background that makes breeding programs more efficient (Taneva et al., 2019) and for identifying parents that will generate transgressive segregations (Patro & Ravisankar, 2004). The maternal factor is often involved in epigenetic phenomena, associated with the modification of gene expression (Richards, 2006; Bird, 2007) and greatly affect the phenotype (Bossdorf, 2008).

The maternal form is a physiological environment for the development of the embryo and the seed and can influence the germination, competitiveness and/or fertility of the offspring (Wolf, 2000; Latzel, 2009), the quality and size of the seeds, thus determining the growth and development potential of the offspring plants (Sills, 1995).

The aim of our research was to determine the effect of the parental factor on the tomato genotype x temperature interactions, the degree of dominance and the cluster organization of the parents and F_1 hybrids, based on growth and development characters.

MATERIALS AND METHODS

As initial material for the intended researches, 5 reciprocal F_1 hybrid combinations were used: Dolgonosic x Mary Gratefully/Mary Gratefully x Dolgonosic, Flacara x Vrojainii/ Vrojainii x Flacara, Flacara x Desteptarea/ Desteptarea x Flame, L 10B x Rufina/Rufina x L 10B, Rufina x Flacara/Flacara x Rufina and 7 parental forms: Rufina, Dolgonosic, Flacara, L 10B, Vrojainii, Mary Gratefully, Desteptarea.

The testing of the tomatoes reaction to high temperature was carried out under controlled conditions. Seeds of parental forms and F_1 hybrids were placed in Petri dishes between 2 sheets of filter paper moistened with 6 ml of distilled water. For each genitor/F_1 hybrid, 9 Petri dishes with 30 seeds were used, of which 3 boxes were kept constant for 7 days at the optimal temperature of 25°C (control). In the case of stressful temperatures variants, the seeds were initially maintained for 3 days at the optimal temperature, on the 4th day they were transferred to thermostats with temperatures of 40° and 42°C, 3 dishes in each for 6 hours, after which they were returned to optimal temperature conditions until the 7th day. The growth capacity of the samples at different temperatures (25°, 40°, 42°C) was established based on the length of the embryonic radicle, stem and integral seedling (Mihnea, 2017).

The degree of dominance (h_p) was established based on the formula proposed by Brubaker (1966):

$h_p = F_1 - 0{,}5\ (P_1+P_2)/\ H_p - 0{,}5\ (P_1+P_2)$,

where: F_1 - the average value of the character in the F_1 generation;

P_1, P_2 - the average value of the character in the parental forms;

H_p - the average value of the character evaluated at the best parental form.

The effect of reciprocity was calculated according to the formula:

$r_e = (b - a)/(B - A)$,

where: A and B - character values for the parental forms involved in crossing; a - for the ♂A x ♀B hybrid; b - for the reciprocal hybrid ♂B x ♀A. The positive value r ($r > 0$) signifies the paternal effect, and negative ($r < 0$) - maternal, the absolute value r ($|r|$) shows the relative appreciation of these effects in units, equal to the differences in the character values of the parental forms (B - A) (Reinhold, 2002).

The cluster analysis of the degree of similarity/difference of tomato genotypes based on growth and development characters at different temperatures was performed based on the iterative algorithm for building dendrograms and the *k*-means centroid method - methods successfully used in genetics and breeding research (Lupaşcu et al., 2019; Kanavi, 2020).

The obtained data were statistically processed in the STATISTICA 7 software package.

RESULTS AND DISCUSSIONS

The analysis of the reaction of some parent varieties and reciprocal F_1 hybrids in response to the influence of different temperature levels on the growth characters of tomatoes in early ontogenesis, demonstrated that the reaction of

the plants to the 3 temperature levels (25°C - optimal, 40° and 42°C - stressful) was differentiated - specific to the genotype, the hybrid, the crossing orientation, the analyzed character: the length of the radicle, stem and seedling.

The length of the radicle. In the parental forms, it was found that in optimal conditions the character varied within the limits of 24.2-49.2 mm, at 40°C - 12.4-36.9 mm, 42°C - 16.2-39.3 mm (Figure 1A). The degree of inhibition of the growth of the parental forms under the influence of the temperature 40°C constituted 14.1-56.4%, and of the temperature 42°C - 22.8-61.4%, compared to the optimal conditions. Significant inhibition of radicle growth was observed in genotype L 10B (61.4%) and stimulation of 7% in variety Rufina. In the case of reciprocal F_1 hybrids, a strongly differentiated reaction was manifested in Dolgonosic x Mary Gratefully: -49.0 ... +7.0% and Flacara x Vrojainii: -9.1 ... -30.8%, and the most insignificant – in Vrojainii x Flacara: - 0.8...-1.1%.

Stem length. In the control variant, the character varied within the limits of 13.5 ... 24.6 mm (Figure 1B). The temperature of 40°C caused growth inhibition which was 18.4-62.2% of the control. Significant repressions were recorded in the variety Rufina (62.2%) and the line L 10B (55.2%). The degree of inhibition in the hybrid combinations varied within wide limits - 2.1 ... 26.5%. Lack of reaction showed the combination F_1 L 10B x Rufina, and significant stimulations - F_1 Flacara x Vrojainii, F_1 Rufina x Flacara (Figure 1 B).

The reaction of the tomato stem at the temperature of 42°C was different: lack of sensitivity to the F_1Vrojainii x Flacara combination and stimulation to the Dolgonosic variety, the F_1 Rufina x Flacara hybrid - 14.6 and 47.0%, respectively. The strongest influence of temperature on the length of the stem was attested to L 10B, F_1 Flacara x Desteptarea: -62.6 and -43.5%, respectively (Figure 1 B).

Seedling length. It was observed that the temperature of 40°C produced the decrease of the character in the parental forms by 11.5...56.3%, and in the reciprocal hybrids by 0.5...40.7% of the control. Pronounced decrease in seedling length was recorded in the variety Rufina, line L 10B, hybrids F_1 Flacara x Desteptarea, F_1 Rufina x Flacara which varied within the limits: 39.1... 56.3%. Less sensitive was Desteptarea: -11.5%, F1Vrojainii x Flacara: -3.7%, F_1 Desteptarea x Flacara: -10.7%, compared to the control (Figure 1C). It was found that the temperature of 42°C in the most of the cases inhibited the growth of the seedling. For example, in L 10B and F_1 Rufina x L 10B the inhibition was 61.7 and 44.7% of the control. Only in the F_1 Rufina x Flacara combination was stimulation recorded, which constituted 36.4%.

It should be noted that in some cases, there were significant differences in the indices analyzed in the reciprocal hybrids, both in the control variant and in the variants with stressful temperatures. For example, both in the case of the length of the radicle, stem and seedling, in the control version, in the hybrids F_1 Rufina x Flacara, F_1 Rufina x L 10B, the length of the radicle was 26.4 and 37.5%, the length of the stem - 37.8 and 43.5%, and of the seedling - 29.4% and 39.2, respectively, lower than in the reciprocal analogues. Significant differences were also found in variants with stressful temperatures. Thus, in the case of temperatures of 40°C and 42°C, significant differences between the reciprocal analogues were found in the combinations F_1 Flacara x Rufina, F_1 Rufina x L 10B (Figure 1 A, B).

The differences manifested in reciprocal F_1 hybrids demonstrate the involvement of the parental factor as an entity of hybridization components in the formation of growth characters under the influence of different temperatures.

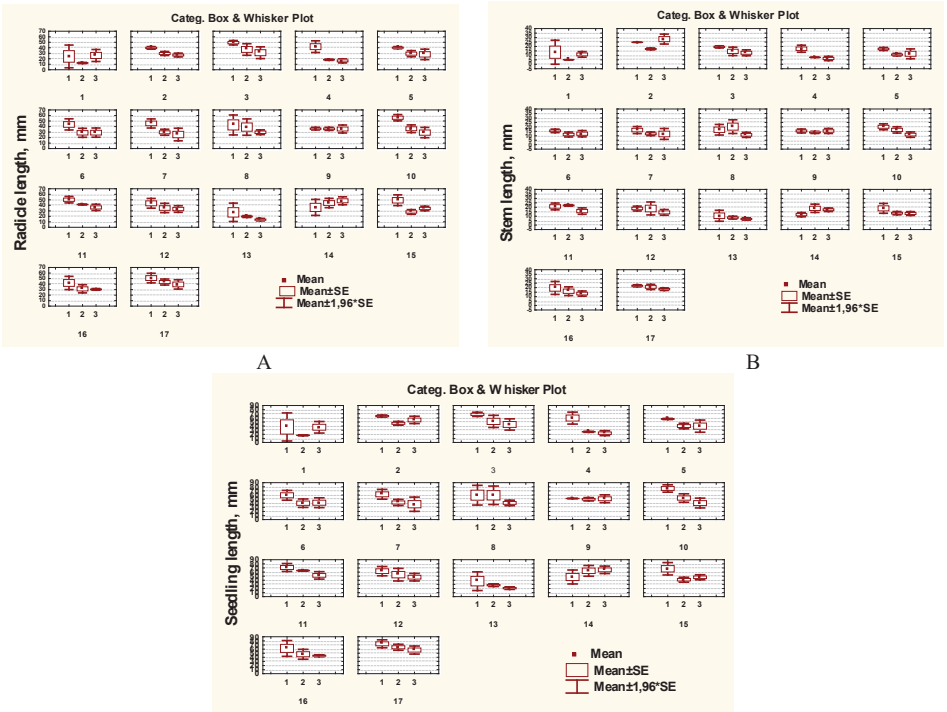

Figure 1. The influence of temperature on the length of the radicle (A), the stem (B) and the intact tomato seedling (C)
Horizontally: 1 - Control (25°C); 2 - 40°C; 3 - 42°C
1 - Rufina, 2 - Dolgonosic, 3 - Flacara, 4 - L 10B, 5 -Vrojainii, 6 - F_1 Dolgonosic x Mary Gratefully, 7 - F_1 Mary Gratefully x Dolgonosic, 8 - F_1 Flacara x Vrojainii, 9 - F_1 Vrojainii x Flacara, 10 - F_1 Flacara x Desteptarea, 11 - F_1 Desteptarea x Flacara, 12 - F_1 L 10B x Rufina, 13 - F_1 Rufina x L 10B, 14 - F_1 Rufina x Flacara, 15 - F_1 Flacara x Rufina, 16 - Mary Gratefully, 17 – Desteptarea

Cluster analysis by constructing dendrograms based on the agglomerative-iterative algorithm demonstrated that the tomato genotypes differed significantly based on the reaction of the embryonic radicle, stem and seedling both under optimal and stressful conditions. The distribution based on Euclidean distances highlighted the formation within the evaluated set of genotypes of distinct clusters: 3 under optimal conditions (Figure 2 A) and 4 under stressful conditions (Figure 2 B, C).

The degree of similarity between tomato genotypes according to the reaction of growth organs at different temperature levels was different. For example, under optimal conditions, genotypes 3, 10; 2, 17; 7, 13, recorded the highest similarity, confirmed by the smallest Euclidean distance for all evaluated characters. The differences between these genotypes were accentuated in the case of stressful temperatures, which led to their location in different clusters.

It was found that the intercluster variance was higher than the intracluster variance at all 3 temperatures, which indicates that the tomato F_1 parents and hybrids were successfully clustered based on the 3 characters under study. Through the ratio of intercluster variance to intracluster variance, it was found: 1) the length of the stem showed a diminished discriminatory capacity compared to other 2 characters; 2) the variability of the tested genotypes decreased at the temperature of 42°C, which could be explained by the fact that this temperature level approaches the limits of the adaptive possibilities of tomato plants. Thus, the most successful differentiation of varieties and F_1 hybrids occurred at the temperature of 40°C (Table 1).

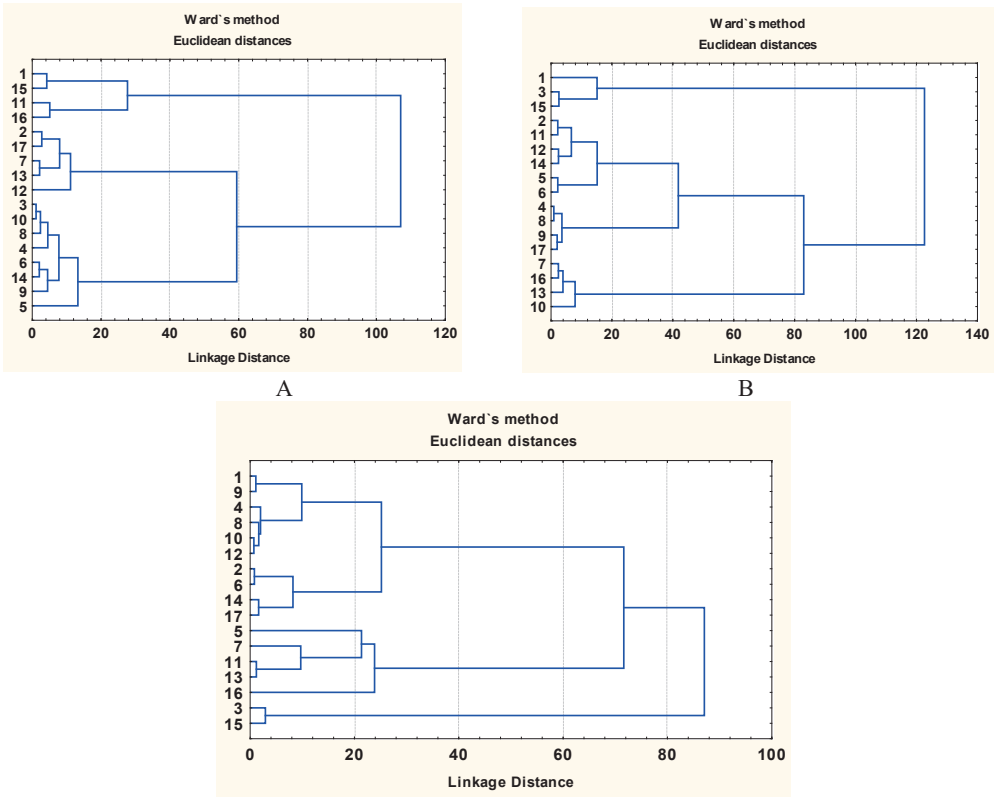

Figure 2. Distribution dendrogram of F_1 tomato varieties and hybrids based on growth characteristics in optimal conditions: A - 25°C and thermal stress, B - 40°C, C - 42°C
1 - Rufina, 2 - Flacara, 3 - L 10B, 4 - Vrojainii, 5 - Dolgonosic, 6 - Mary Gratefully, 7 - Desteptarea, 8 - F1 Dolgonosic x Mary Gratefully, 9 - F_1Mary Gratefully x Dolgonosic, 10 - F_1Flacara x Vrojainii , 11 - F_1 Vrojainii x Flacara, 12 - F_1 Flacara x Desteptarea, 13 - F_1 Desteptarea x Flacara, 14 - F_1 L 10B x Rufina, 15 - F_1 Rufina x L 10B, 16 - F_1 Rufina x Flacara, 17 - F_1 Flacara x Rufina

Table 1. Analysis of inter- and intracluster variance in the interaction of tomato genotypes with different temperature levels

Variant	Intercluster variance	df	Intracluster variance	Ratio	df	F	p
25°C							
The length of the radicle	894.788	2	171.4969	5.22	14	36.52262	0.000003
The length of the stem	122.963	2	84.587	1.45	14	10.17574	0.001868
Seedling length	1703.801	2	220.3010	7.73	14	54.13780	0.000000
40°C							
The length of the radicle	1101.836	2	158.1685	6.97	14	48.76352	0.000000
The length of the stem	305.844	2	72.7750	4.20	14	29.41816	0.000010
Seedling length	2576.107	2	333.6302	7.72	14	54.05012	0.000000
42°C							
The length of the radicle	705.529	2	309.4120	2.28	14	15.96158	0.000245
The length of the stem	256.028	2	122.7210	2.09	14	14.60385	0.000375
Seedling length	1764.502	2	256.9770	6.87	14	48.06466	0.000001

By classifying the genotypes based on the 3 characters, it was found that in the control variant cluster 2 met 3 genotypes - 1, 15, 16 with the lowest values of the analyzed characters, and cluster 3 - the genotypes with the highest values (Table 2).

Table 2. Descriptive cluster analysis

Cluster	Character	x	Genotype
Control			
1	The length of the radicle, mm	41.79	3 – L 10B, 4 – Vrojainii, 5 – Dolgonosic, 6 – Mary Gratefully, 8 – F_1 Dolgonosic x Mary Gratefully, 9 – F_1 Mary Gratefully x Dolgonosic 10 – F_1 Flacara x Vrojainii, 11 – F_1Vrojainii x Flacara, 14 – F_1 L 10B x Rufina
	The length of the stem, mm	17.92	
	Seedling length, mm	59.69	
2	The length of the radicle, mm	29.30	1 – Rufina, 15 – F_1 Rufina x L 10B, 16 – F_1 Rufina x Flacara
	The length of the stem, mm	11.90	
	Seedling length, mm	41.20	
3	The length of the radicle, mm	51.08	2 – Flacara, 7 – Desteptarea, 12 – F_1 Flacara x Desteptarea, 13 – F_1 Desteptarea x Flacara, 17 – F_1 Flacara x Rufina
	The length of the stem, mm	19.84	
	Seedling length, mm	71.34	
Temperature 40°C			
1	The length of the radicle, mm	16.80	1 – Rufina, 3 – L 10B, 15 – F_1 Rufina x L 10B
	The length of the stem, mm	7.10	
	Seedling length, mm	23.87	
2	The length of the radicle, mm	32.03	2 – Flacara, 4 – Vrojainii, 5 – Dolgonosic, 6 – Mary Gratefully, 8 – F_1 Dolgonosic x Mary Gratefully, 9 – F_1Mary Gratefully x Dolgonosic, 11 – F_1Vrojainii x Flacara, 12 – F_1 Flacara x Desteptarea, 14 – F_1 L 10B x Rufina, 17 – F_1 Flacara x Rufina
	The length of the stem, mm	14.45	
	Seedling length, mm	46.48	
3	The length of the radicle, mm	42.13	7 – Desteptarea, 10 – F_1Flacara x Vrojainii, 13 – F_1 Desteptarea x Flacara, 16 – F_1 Rufina x Flacara
	The length of the stem, mm	20.45	
	Seedling length, mm	62.63	
Temperature 42°C			
1	The length of the radicle, mm	29.64	1 – Rufina, 2 – Flacara, 4 – Vrojainii, 6 – Mary Gratefully, 8 – F_1 Dolgonosic x Mary Gratefully, 9 – F_1 Mary Gratefully x Dolgonosic, 10 – F_1 Flacara x Vrojainii, 12 – F_1 Flacara x Desteptarea, 14 – F_1 L 10B x Rufina, 17 – F_1 Flacara x Rufina
	The length of the stem, mm	12.29	
	Seedling length, mm	41.94	
2	The length of the radicle, mm	15.10	3 – L 10B, 15 – F_1 Rufina x L 10B
	The length of the stem, mm	6.70	
	Seedling length, mm	21.85	
3	The length of the radicle, mm	37.22	5 – Dolgonosic,7 – Desteptarea, 11 – F_1Vrojainii x Flacara, 13 – F_1 Desteptarea x Flacara, 16 – F_1 Rufina x Flacara
	The length of the stem, mm	18.96	
	Seedling length, mm	56.18	

In the variant with temperature 40°C, 3 genotypes - 7, 10, 13, 16, and in the case of temperature regime 42°C 5 of the genotypes – 5, 7, 11, 13, 16 formed cluster 3, with the highest values of the evaluated characters. From the data obtained we can conclude that genotypes 7, 13 and 16 show complex resistance to the mentioned temperature stresses and are of interest in their use as sources of resistance to unfavorable temperatures. The processing of the experimental data through factorial analysis of variance allowed the appreciation of the variability and the degree of influence of temperature, genotype and their interaction in the weight of the phenotypic manifestation of the growth and development characters of the investigated tomato genotypes (Table 3).

Table 3. Bifactorial analysis of tomato *genotype x temperature* relationships

Source of variation	Freedom degree	The length of the radicle		The length of the stem		Seedling length	
		Mean sum of squares	Contribution in the source of variation, %	Mean sum of squares	Contribution in the source of variation, %	Mean sum of squares	Contribution in the source of variation, %
Genotype	16	448.3*	15.8	125.7*	32.8	913.3	18.1
Temperatur e	2	2231.9*	79.0	216.8*	56.5	3823.9	75.9
Genotype x temperature	32	89.7*	3.2	27.9*	7.3	186.1	3.7
Random effects	102	56.8	2.0	13.0	3.4	117.1	2.3

*- $p<0.05$.

The mean sum of squares for the 3 characters analyzed was the highest in the case of temperature as a source of variation: 2231.9 - radicle, 448.3 - stem, 3823.9 - whole seedling, followed by genotype and *genotype x temperature* interactions.

By calculating the percentage weight in the source of character variation, it was found that the contribution of genotype, temperature and *genotype x temperature* interactions for radicle length was 15.8, 79.0, 3.2%; stem - 32.8, 56.5, 7.3% and seedling - 18.1, 75.9, 3.7%. So, the variability of the lengths of the embryonic radicle, stem and seedling depends the most on temperature, although the role of the genotypic factor is not negligible, which constituted 15.8, 32.8, 18.1%, respectively, of the mentioned characters. Thus, stem length depended on genotype to a greater extent than other two characters under study. The length of the whole seedling was largely determined by the length of the radicle, this being confirmed by the comparable weight (15.8, 18.1%) of the genotype in the source of variation of these characters. From the data presented, it can be seen that the role of *genotype x temperature* interactions was not relevant (2.0-3.4%) (Table 3).

The research of the role of the parental factor on the growth of tomato radicle, stem and seedling under optimal conditions (25°C), demonstrated that in all variants, except for the combination Dolgonosic x Mary Gratefully / Mary Gratefully x Dolgonosic for stem length and seedling length, Flame x Awakening/ Awakening x Flame for radicle and seedling length, the stronger influence of paternal form was manifested. It should be noted that compared to the control variant, the role of the maternal factor was more pronounced at 42^0C, the effect of reciprocity registering values of -1.97...- 4.92 for the radicle length; -1.6... -3.64 – stem length; -1.87...-2.65 - seedling length (Table 4).

Table 4. Parental effect on tomato growth organs under optimal and stressful conditions

F_1 hybrid	The length of the radicle			The length of the stem			Seedling length		
	25^0C	40^0C	42^0C	25^0C	40^0C	42^0C	25^0C	40^0C	42^0C
Dolgonosic x Mary Gratefully	+0.82	+0.56	-3.01	-0.18	-0.67	+0.02	-0.89	+1.8	+0.32
Flacara x Vrojainii	+0.77	+0.42	-4.92	+0.54	+1.73	-3.64	+0.7	+0.86	-2.43
Flacara x Desteptarea	-3.4	+0.81	+0.87	+0.36	+0.89	+0.81	-1.12	+0.84	+0.85
L 10B x Rufina	+0.92	+2.61	-1.97	+2.08	+3.70	-1.61	+1.12	+3.01	-1.87
Rufina x Flacara	+0.52	-0.67	-2.74	+1.18	-0.57	-2.33	+1.47	-0.64	-2.65

The data obtained show the need to take into account the orientation of hybridization component crosses in tomato in order to make the most successful use of the biological potential of the parents for the creation of resistant forms. The parental factor also influenced the degree of dominance (h_p) of growth characters. For example, in the control variant h_p for the length of the radicle varied within the limits of -1.9...+7.25, and in the

variants with temperatures of 40, 42°C - within the limits of -2.1...+6.79 and -1.67...+7.84 - i.e. between the predominance of the parent with the highest radicle growth values - to the predominance of the parent with the lowest values, which denotes the existence of specific interactions of the alleles of the two genomes, function of the character, combination and temperature level.

In the control variant, the degree of dominance of the stem length character varied within wide limits - from positive overdominance (+1.63) to negative overdominance (-2.64). In variants with stressful temperatures, the rate of combinations with positive overdominance increased. Thus, if in optimal conditions the positive predominance was registered with a combination - L 10B x Rufina (+1.63), at the temperature of 40^0C it was registered with 5 hybrids (+1.45 ... +9.0), and at the temperature of 42^0C - with 4 hybrids (+1.11 ... +5.78). Regarding seedling length in the control variant, the degree of dominance varied within the limits: -6.14...+ 1.25, and in the variant with stressful temperatures: -23.7...+7.60 and -1.53... +6.52 to the 40^0C and 42^0C temperatures, respectively (Table 5).

It should be noted that at the reciprocal hybrids, differences in the degree of dominance were found in terms of the level of manifestation, as well as the orientation of dominance, which largely depends on the orientation of the cross, the tested organ and the temperature level. In the variant with stressful temperatures, in most cases the differences between reciprocal hybrids were stronger than under optimal conditions.

For example, out of 5 pairs of reciprocal hybrids only in the combinations Dolgonosic x Mary Gratefully/Mary Gratefully x Dolgonosic the differences for stem length were insignificant both under optimal and stressful conditions, in the other F_1 reciprocal hybrids the values, but sometimes also the h_p orientation have were different, which demonstrates once again the influence of the parental factor on the phenotype of tomato root, stem and seedling (Table 5).

Table 5. The influence of the parental factor on the degree of dominance of growth and development indices in tomato at different temperatures

F_1 hybrid	The length of the radicle			The length of the stem			Seedling length		
	25°C	40°C	42°C	25°C	40°C	42°C	25°C	40°C	42°C
Dolgonosic x Mary Gratefully	+2.63	-2.1	+0.22	-2.64	-8.67	-1.15	+0.20	-23.7	-1.48
Mary Gratefully x Dolgonosic	+4.27	-1.0	-1.67	-2.28	-7.3	-1.19	+0.59	-17.7	-2.11
Flacara x Vrojainii	-0.40	+1.55	+0.07	-1.3	+4.17	-2.17	+0.15	+2.41	-0.57
Vrojainii x Flacara	-1.90	+0.79	+4.0	-2.4	+0.61	+5.17	-0.61	+0.68	+2.86
Flacara x Desteptarea	+7.25	-1.26	-1.49	-0.67	-0.32	-1.59	-6.14	-0.9	-1.53
Desteptarea x Flacara	+0.13	+0.35	+0.24	+0.08	+1.45	+0.04	+0.19	+0.86	+0.16
L 10B x Rufina	+1.19	+6.79	+2.49	+1.63	+9.0	+2.39	+1.25	+7.60	+2.48
Rufina x L 10B	-0.65	+1.48	-1.43	-2.63	+7.0	-0.8	-1.01	+1.5	-1.28
Rufina x Flacara	-0.03	+1.61	+7.84	-1.6	+1.91	+5.78	-0.34	+1.69	+6.52
Flacara x Rufina	+1.0	+0.27	+2.24	+0.67	+0.85	+1.11	+0.95	+0.41	+1.82

CONCLUSIONS

The analysis of the growth characteristics of the radicle, stem and seedling of the tomato F_1 parents and hybrids at different temperature levels highlighted the differentiated nature of the reaction of the genotypes under study. In the most cases stressful temperatures produced significant inhibition of tomato growth organs.

The manifestation of significant differences in the characters analyzed in most of the reciprocal F_1 hybrids both in the control variant (25°C) and in the variants with stressful temperatures (40°, 42°C) demonstrates the involvement of the parental factor in the reaction and the formation of the phenotype of the growth characters at different temperature levels. The maternal effect was more pronounced at the temperature of 42°C than under optimal conditions, which indicates the need to take into account the resistance of parental forms when making decisions about the orientation of crosses of hybridization components in order to reduce the effects of stressful temperatures on tomato growth organs in early ontogeny.

According to the degree and orientation of dominance of growth characters in reciprocal F_1 tomato hybrids at different temperatures, the interaction of maternal and paternal genes is strongly influenced by the thermal factor. It was established that in the F_1 L 10B x Rufina and F_1 Rufina x Flacara combinations, the evaluated characters showed, under stressful conditions, overdominance in relation to the best parent, which indicates that in these conditions, the parental entity intensifies the influence of the recessive alleles on the dominant, involved in the control of growth characters of tomato plants.

Through cluster analysis (*k*-means) tomato parents and F_1 hybrids were identified - Dolgonosic, Desteptarea, F_1Vrojainii x Flacara, F_1 Desteptarea x Flacara, F_1 Rufina x Flacara with high resistance to temperature 42°C, which provides opportunities for their use in breeding programs as reliable sources of resilience.

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