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COMPARATIVE ANALYSIS OF RESISTANCE TO HIGH TEMPERATURE STRESS IN PROSPECTIVE TOMATO LINES

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Abstract. *The paper presents the results of the evaluation of tomato lines obtained as a result of intraspecific hybridization based on resistance to high temperatures (40°, 42°C) in early ontogenesis. Seedlings grown at 25°C served as a control variant. The analysis of the variability of the resistance trait was carried out based on the length of the embryonic radicle, stem, and whole plantlet length. It was found that at a temperature of 40°C all lines showed increased resistance to growth traits, and at a temperature of 42°C a significant inhibition of the radicle, stem, and whole plantlet length was observed. Through cluster analysis (k-means) the variety Prestij and lines 203, 204, 205 were identified with complex resistance of growth characters to high temperatures (40 and 43°C), which can be implemented in breeding programs to create varieties with complex resistance to thermal stress.*

Keywords: tomato, resistance, temperature, variability.

INTRODUCTION

Temperature is one of the main environmental factors that influences the entire range of vital processes of vegetable plants: seed germination, plant growth, flowering, fruiting, as well as assimilation, respiration, transpiration and other physiological processes that normally occur only in the presence of an optimal temperature. Climate change represents one of the main challenges of humanity which will thus require the implementation of new strategies for adapting newly created varieties in a timely manner to local conditions in order to reduce the effect of stress temperatures [1, 2].

High temperatures have a negative impact on several physiological processes in the plant (disruption of the functioning of the photosynthetic apparatus

components, a number of enzymes in mitochondria and other cellular components [3, 4, 5], which leads to a decrease in plant productivity [6, 7].

In many species, including tomatoes, productivity decreases due to a decrease in fruit set during high-temperature seasons. Previous research has shown that resistant tomato genotypes have the ability to form a much larger number of fruits than susceptible ones under stress conditions [8,9].

The purpose of our research was to evaluate the influence of high temperatures on the growth and development traits of promising tomato lines in the selection field and to identify those with potential for use in breeding programs.

MATERIALS AND METHODS

The Prestij variety and 8 lines selected from the intraspecific combinations F_4 Mary Gratefully x Florina (L 202), F_4 Deşteptarea x Florina (L 203, L 204, L 205), F**4** Prestij x Pontina (L 206), F_6 Zolotaia oseni x L 310 (L 207), F_5 Santa Maria x Rozovîi velican (L 208), F_4 Deşteptarea x Pontina (L 209) served as the research material.

The genotypes were tested at 3 temperature levels: optimum – 25°C and heat stress: 40 and 42°C. The assessment of the resistance of tomato genotypes to high temperatures was carried out according to the growth capacity of the embryonic radicle, stem and intact seedling for 7 days after maintaining them on day 4 at temperatures of 40° and 42°C for 6 hours [10]. Seedlings kept constantly at 25°C served as a control. The resistance of the plants (%) was calculated according to the ratio of the values of the investigated characters from the stress variant to the control variant, and the tomato samples were differentiated by resistance groups: 81-100% – highly resistant, 61-80% – resistant, 41-60% – medium resistant, weakly resistant 21-40% and 0-20% – non-resistant.

The cluster analysis of the degree of similarity / difference of tomato genotypes based on growth and development characters at different temperatures was carried out according to the centroid method of *k*-means, successfully used in the genetics and improvement research [11]. The obtained data were statistically processed in the STATISTICA 7 software package.

RESULTS AND DISCUSSION

The evaluation of the perspective lines based on the reaction of tomato plants to high temperatures demonstrated that under the action of temperature stress, in most of the genotypes studied there was a strong inhibition of growth characters. As can be seen from the data presented (Fig. 1) the influence of stressful temperatures on the growth of the embryonic radicle, stem and whole plantlet in the tomato genotypes included in the study is different. The length of the radicle in the

lines studied under optimal conditions was 39,2...67,3 mm, at 40°C – 46,3...58,3 mm, and 42°C – 22,7...32,8 mm, respectively (Fig. 1A). The decrease in the character in relation to the control varied within the limits of 3,3...21,0% at 40°C, and the resistance was 84,5 – 117,3%. Stimulation by 17,3% at 40^0C was recorded in line L 204 selected from the F_4 combination Deşteptarea x Florina. The data obtained show that all lines analyzed are characterized by increased resistance, even at 40^0C.

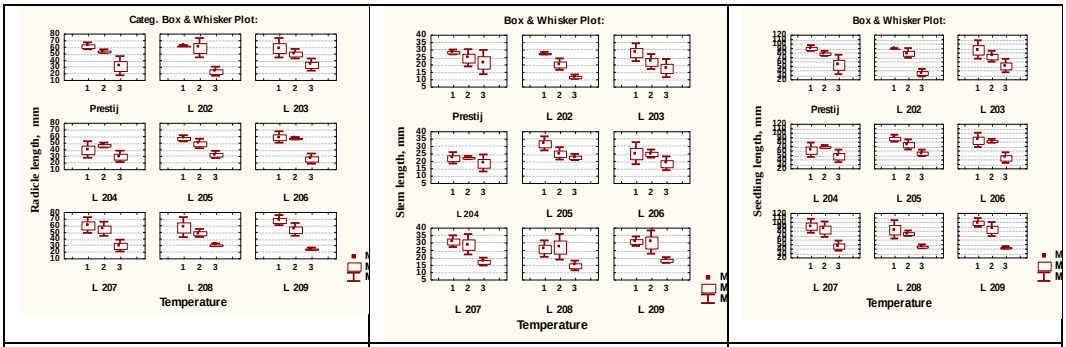


Fig. 1. Influence of temperature on the length of the radicle (A), stem (B) and seedling (C) of tomato
Horizontally: 1 – Martor (25˚C), 2 – 40˚C, 3 – 42˚C.

Under the action of the 42^0C temperature, the growth of the embryonic radicle was repressed in all the analyzed forms, its values representing -49,1%, -62,6%, -43,6%, -26,3%, -43,6%, -56,4%, -52,2%, -47,1%, -64,3% in relation to the control, and their resistance was 50,9%, 37,1%, 56,4%, 73,7%, 56,4%, 43,6%, 47,3%, 52,9%, 35,7%, respectively, for the Prestij variety and the L 202-L 209 lines. So, with the exception of the L 204 line which showed a lower depression reaction, in the other genotypes a repression of more than 43,0% of the radicle length occurred, which denotes stronger sensitivity to temperature 42^0C. Complex resistance was manifested by the L 204.

A wide amplitude of stem length variability was also recorded in response to stress temperatures. Stem inhibition relative to the control at 40°C ranged from 2.0 to 27,3%, and at 42^0C, from 16,1 to 57,9% (Fig. 1B). The most strongly influenced by 420C were the lines L 202, L 207, L 208 and L 209. Stimulation was observed in two cases at 40^0C, L 204 (1,4%) and L 208 (5,1%). It is worth mentioning that the stem was less affected by thermal stress, and if in the case of the radicle, complex resistance was manifested by only one line, then in the case of the stem, complex resistance was manifested by the variety Prestij and the lines L 204, L 205 and L 206, in which the resistance at a temperature of 40°C was 85,8,

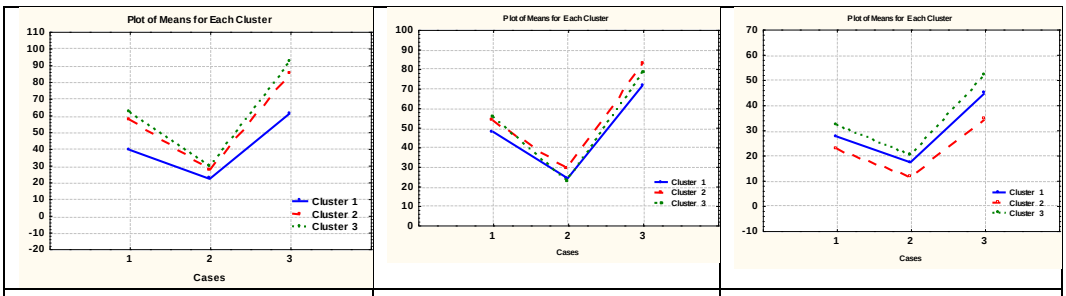
101,4, 78,5, 99,2%, and at 42°C – 75,5, 83,9, 70,9, 72,7%, respectively.

The reduction in seedling length compared to the control ranged from 2,5 ... 17,7% at 40^0C and 22,6 ... 61,6% - 42^0C. At the same time, the temperature of 42^0C most strongly influenced the lines L 202 (61,6%), L 209 (57,2%). (Fig.1C). Complex resistance to stress temperatures based on this character was manifested by the lines L 204 and L 205, showing interest in breeding.

By the cluster analysis which recorded that the intercluster variance was much higher than the intracluster variance in the case of radicle, stem and seedling length both under optimal and heat stress conditions, we can conclude that the tomato genotypes were successfully classified into clusters based on growth characters (Tab. 1, Fig. 2).

Table 1. Analysis of variance of growth traits in the interaction of tomato genotypes with different temperature levels

Variant	Intercluster variance	df	Intracluster variance	df	F	p
25°C						
Length of the radicle	430,0947	2	36,68750	6	35,16959	0,000486
Length of the stem	43,5806	2	35,95500	6	3,63626	0,092383
The seedling length	750,7125	2	69,22748	6	32,53242	0,000602
40°C						
Length of the radicle	120,4983	2	20,10166	6	17,98334	0,002922
Length of the stem	54,3658	2	32,79417	6	4,97337	0,053265
The seedling length	202,3058	2	27,43417	6	22,12269	0,001703
42°C						
Length of the radicle	73,3409	2	28,01467	6	7,85384	0,021116
Length of the stem	60,8556	2	25,36666	6	7,19711	0,025464
The seedling length	267,8275	2	24,58801	6	32,67782	0,000595



A B C

Figure 2. Differentiation of genotype clusters under optimal conditions (A) – 25°C and heat stress B (40°C), C (42°C)

Growth characters: 1 – radicle length, 2 – stem length, 3 – seedling length

By classifying the genotypes based on the evaluated characters, it was found that in the variant with the temperature regime of 40°C, the Prestij variety and the lines L 202, L 206, and at the temperature of 42°C the Prestij variety and the lines L 203 and L 205, formed clusters with the highest values of growth characters, which denotes that they are promising in creating new varieties resistant to high temperatures.

Table 2. Descriptive cluster analysis

Cluster	Caracter	x	Genotype	x	Genotype	x	Genotype
		25°C		40°C		42°C	
1	Length of the radicle, mm	39,20	L 204	47,85	L 203, L 204, L 205, L 208	27,42	L 204, L 206, L 207, L 208, L 209
	Length of the stem, mm	21,80		23,87		17,10	
	Length of the seedlings, mm	61,00		71,47		44,52	
2	Length of the radicle, mm	57,30	L 203, L 205, L 206, L 208	53,65	L 207, L 209	22,70	L 202
	Length of the stem, mm	27,52		29,30		11,50	
	Length of the seedlings, mm	84,62		83,00		34,10	
3	Length of the radicle, mm	62,37	Prestij, L 202, L 207, L 209	55,93	Prestij, L 202, L 206	31,87	Prestij, L 203, L 205
	Length of the stem, mm	29,17		22,93		20,337	
	Length of the seedlings, mm	91,60		78,87		52,207	

CONCLUSIONS

It was found that the temperature of 42ºC compared to the temperature of 40ºC significantly influences the early ontogenesis of tomato genotypes by strongly repressing the growth of the radicle, stem and seedling.

Cluster analysis using the k-means method showed that both the optimal and stressful temperature exhibited a high discriminant capacity of tomato clusters for all characters, which reveals that the tomato genotypes were successfully classified into clusters based on growth characters.

The variety Prestij and lines 203, 204, 205 with complex resistance of growth characters to high temperatures (40 and 43ºC) were identified, which can be successfully implemented in breeding programs for the creation of varieties with complex resistance to thermal stress.

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