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EVALUATION OF PARENTAL FORMS AND HYBRID POPULATIONS DESCENDING FROM TOMATOES, FOLLOWING HEAT RESISTANCE AND PRODUCTIVITY

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Abstract

Climate change has a negative impact on agriculture. In the last decade, drought and high temperatures have become more frequent with strong negative effects on crop productivity. Selection based on resistance to extreme temperatures now becomes the actual objective because in some years, the air temperature reaches 35-45ºC during the flowering stage of the day, which considerably reduces fruits setting and the yield per hectare. The aim of our research was to test the level of heat resistance of genotypes and hybrid populations descending from tomatoes to select the forms with high resistance level. As a result of research we found that the highest resistance to heat was manifested by genotypes of F_3 generation Mihaela x Irisca (93.9%) and F_3 Maestro x Irisca (82.9%) and the lowest - by the variety Maestro (31. 2%). The genotypes with increased resistance can be used subsequently in research for genetic breeding for resistance to high temperatures.Testing of the selected material based on the characters complex, including heat resistance, demonstrated the possibility of creating new forms of tomato combining productivity with high air temperatures resistance.

Key words: *tomatoes, intra-specific hybridization, breeding, resistance, heat*

INTRODUCTION

Tomatoes are one of the most common vegetable crops in Moldova and worldwide because of high nutritional value of its fruits, both, for fresh consumption and many types of processed products.

In Moldova, permanently, climate change has had a negative impact on agriculture. We can mention that in the past decade drought and high temperatures have become more frequent, with strong negative effects on crop productivity. Selection based on resistance to extreme temperatures now becomes the actual objective because in some years the air temperature reaches 35-45ºC during the day at the blossoming stage, which considerably reduces fruits setting and the yield per hectare. Therefore, creating tomato genotypes with resistance to extreme environmental factors and high productivity and quality indicators presents a serious improvement (Mihnea et al., 2010; Mihnea, 2011; Mihnea et al., 2005; Moldovanu et al., 2000. Sato et al., 2000; Saltanovici et al., 2003; Saltanovici et al., 2012). According to the author V.L Erşova (1979) the air temperature is of 30-33ºC for most tomato varieties, the pollen losses its fertility, fecundity is compromised, the flowers fall, growth either stops or interrupts and the intensity of photosynthesis decreases. The harmful impact of high temperatures is intensified under deficit of soil water. It has been established that the optimum temperature of pollen germination is from 22 to 26ºC and fruit development - from 20 to 24ºC.

Positive effects of breeding can be achieved by using a sufficient number of genotypes specially selected for certain agro-environmental areas and, at the same time, taking into account the considerable variability of the plants cultivation conditions. Contemporary breeding demonstrates the need to create lines, varieties and hybrids with high environmental resistance. The importance of the adaptive breeding to create varieties combining resistance and stressogenic factors with high productivity factors has been recognized by many researchers (Pivovarov et al, 1990; Kilchevsky, 1997; Zhuchenko, 2005).

The aim of our research was to test the level of heat resistance of genotypes and hybrid

populations for selecting forms descending from tomatoes with the high level of heat resistance.

MATERIALS AND METHODS

The experiments were conducted in the year 2011 under field conditions in the experimental plot of the IGFPP. As the initial material for the planned research were used genotypes selected from F_3 hybrid generations using a character complex of 4 combinations and backcrossing hybrids obtained on the base of intra-specific hybridization of Maesrto x Irisca, Maestro x Dwarf Moneymaker, Maestro x Dwarf Moneymaker, Mihaela x Irisca. Field experiments were conducted in triplicate in randomized blocks of seedlings cultivation without irrigation. The sowing took place in greenhouses in the first decade of April according to the scheme 7 x 10 cm and field planting - in the scheme of 70 x 30 cm. Field planting was performed in the second decade of May, and harvesting was done gradually (4-6).
Caring for and tomato growing were performed in accordance with agro- technical norms adopted in Moldova. High temperature resistance of genotypes was evaluated according to methodological recommendations (Ivakin, 1979) based on plant growth capacity after their exposure to high temperatures (43ºC) for 6 hours. The data obtained were statistically processed using the software STATISTICS 7.
Graphical representation, tabular and textual, was performed through the Microsoft Office and Microsoft Excel software.

RESULTS AND DISCUSSIONS

By testing the response of 4 parental forms and 43 phenotypes of tomatoes selected from four hybrid combinations and backcrossing hybrids obtained on the base of intra-specific hybridization of Maesrto x Irisca, Maestro x Dwarf Moneymaker, Maestro x Dwarf Moneymaker, Mihaela x Irisca hybrids under the impact of high temperatures (43º C) it was established that genotypes/populations selected for two years under field conditions manifested different responses to the heat. The data obtained on the response of tomato hybrid populations at elevated temperatures demonstrated that in some hybrid combinations F_3, F_2BC there were recorded values of high resistance of hybrids obtained in comparison with the genitors, while in some value combinations there were less average parents. The result of evaluating genotypes / populations on heat resistance is shown in Figure 1. Analysis of these forms under heat resistance showed that variability from 31.2 to 93.9% was within the limits. As the data show, a high resistance was demonstrated by genotypes 4, 6, 7, 8 selected from F_2 hybrid combination Maesrto x Irisca, genotypes 11, 13 from the backcross combination F_1BC (Maesrto x Irisca) x Maestro, genotype 15 from combination F_1BC (Maestro x Irisca) x Irisca. According to the degree of resistance to temperatures indicated by genotypes selected from combinations in which as the paternal form was used the variety Dwarf Moneymaker, there were found two genotypes of 21 (5 - F_3 Maestro x Dwarf Moneymaker and 11 -F_1 BC (Mihaela x Dwarf Moneymaker) x Dwarf Moneymaker]) that demonstrated resistance of 77.9% and 60.3%. In terms of the heat response of genotypes selected from the combination Mihaela x Irisca, it was seen that that genotypes 5, 6, 9 (Fig. 1C) demonstrated the resistance of 63.1; 93.9 and 61.4%, respectively. It should be mentioned that most simple and backcrossed hybrid populations showed high values of the resistance level of plants. However, hybrid populations created with participation of Irisca variety had the highest indices of the examined character.
Concerning another examined quantitative indicators - the seedling length that can be considered both, as the genotype peculiarity and the index of resistance to high temperature and it is evident that it differs much from genotypes included in the study (Fig. 2).
Plants length under optimum conditions was within the limits of 70.0 ... 114.2 mm while under stressful conditions - 24.2 ... 66.6 mm in case of the combination Maesrto x Irisca whose parents showed pronounced differences of the analyzed index (24.2 and 41.0 mm); it was found that most offspring had much higher values than the best parents, with the exception of genotypes 10, 16 in which the plant length was 33.9 and 33.2 mm. The offspring from the hybrid combination Mihaela x Irişca (Figure 2

C) showed a higher level of plats growth and was within the limits from 46.6 to 66.6 mm. In genotypes selected from the combination Maestro x Dwarf Money Maker (Figure 1) the plants length under stress was greater than in the parental forms while in combination of Mihaela x Dwarf Moneymaker, only one descendent ceded the best parent.

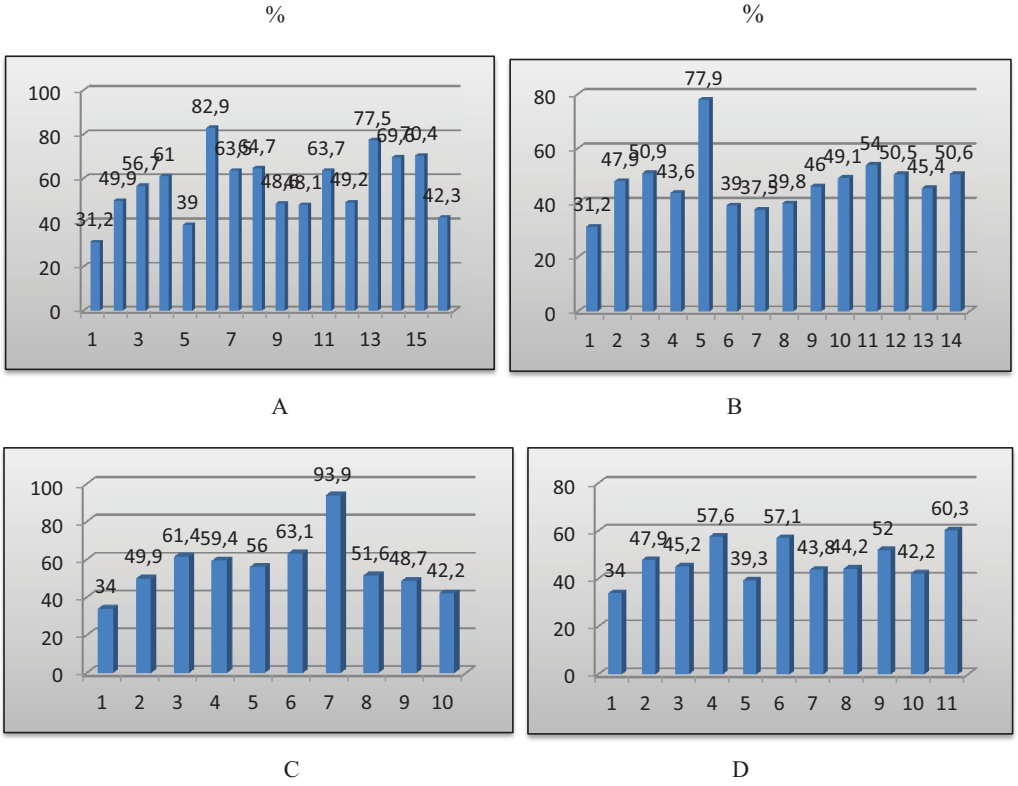


Figure 1. Evaluation of tomato genotypes selected from intra-specific combinations on heat resistance in comparison with parental forms

A. 1 – Maestro, 2 – Irişca, 3-9 – F_3 (Maesrto x Irişca), 10-13 – F_2 BC (Maesrto x Irişca) x Maestro, 14-16 – F_2 BC (Maesrto x Irişca) x Irişca.

B. 1 – Maesrto, 2 - Dwarf Moneymaker, 3-10 – F_3 (Maestro x Dwarf Moneymaker), 11-12 – F_2 BC (Maestro x Dwarf Moneymaker) x Maestro, 13-14 – F_2 BC (Maestro x Dwarf Moneymaker) x Dwarf Moneymaker.

C. 1 - Mihaela, 2 – Irişca, 3-7 – F_3 (Mihaela x Irişca), 8-9 - F_2 BC (Mihaela x Irişca) x Mihaela, 10 – F_2 BC Mihaela x Irişca) x Irişca.

D. 1 – Mihaela, 2 - Dwarf Moneymaker, 3-8 – F_3 (Mihaela x Dwarf Moneymaker), 9-10 – F_2 BC Mihaela x Dwarf Moneymaker) x Mihaela, 11 – F_2 BC (Mihaela x Dwarf Moneymaker) x Dwarf Moneymaker.

Under the influence of temperature of 43^0 C the repression of plant growth occurred in all analyzed forms, whose values were presented in genotypes of the combination MaestRo x Irisca - 31.8; -46.4; -42.5; - 27%; -38.9; -44.0; -41.2; -49.2; -34.9; - 43.9; -29.5; - 53.3 -54.6; -56.0%, while in the combination Mihaela x Irisca -44.; -25 4; -37.9; - 22.8; -31.5; -24.5; -43.9; -57.1% compared with the check. In the combination of Maestro x Dwarf Moneymaker the repression of plant growth was within the limits of 36.9 ... 65.5, while in Mihaela x Dwarf Moneymaker - 42.3 ... 57.9%. Testing of the selected material on the base of the parent sporophyte heat resistance revealed the forms possessing a lower depression of the plants under the thermal stress and high resistance to heat. They were included in the process of further improvement.

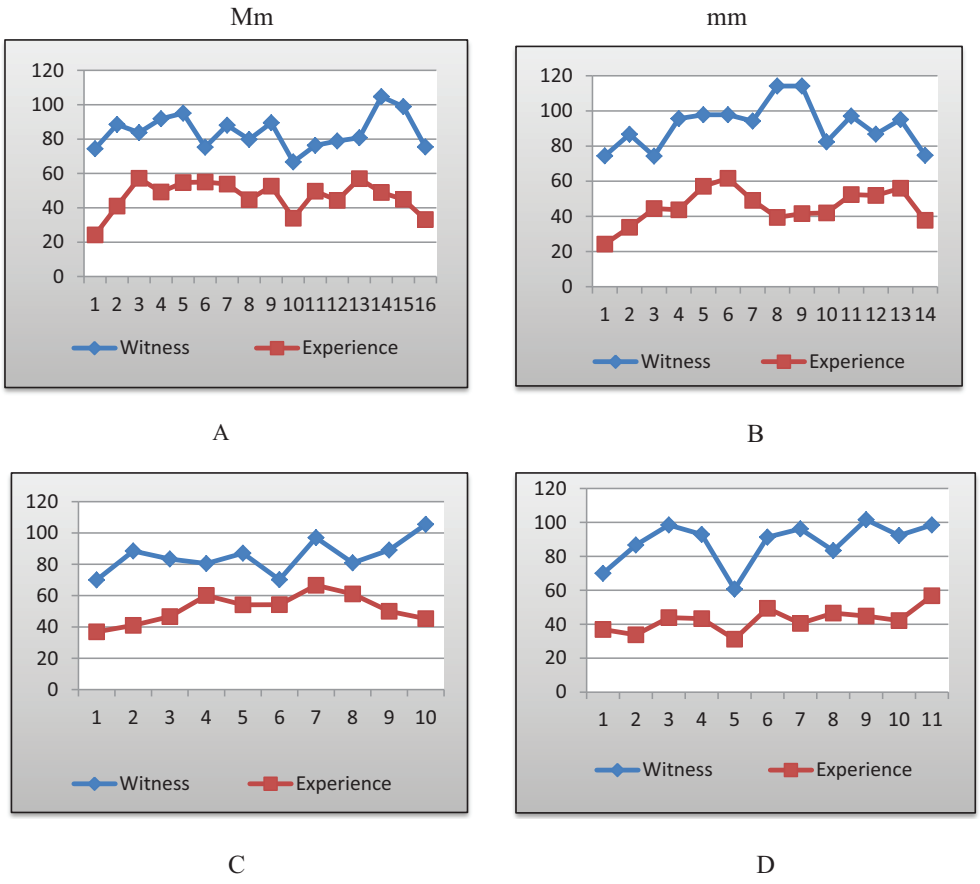


Figure 2. Tomato plant length under optimal conditions (25^0 C) and stress (43^0 C)

A. 1 – Maestro, 2 – Irişca, 3-9 – F_3 (Maesrto x Irişca), 10-13 – F_2 BC (Maesrto x Irişca) x Maestro, 14-16 – F_2 BC (Maesrto x Irişca) x Irişca.

B. 1 – Maesrto, 2 - Dwarf Moneymaker, 3-10 – F_3 (Maestro x Dwarf Moneymaker), 11-12 – F_2 BC (Maestro x Dwarf Moneymaker) x Maestro, 13-14 – F_2 BC (Maestro x Dwarf Moneymaker) x Dwarf Moneymaker.

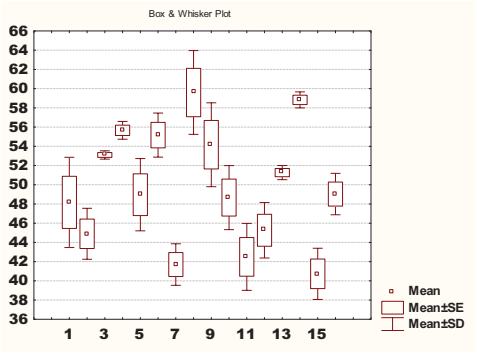
C. 1 - Mihaela, 2 – Irişca, 3-7 – F_3 (Mihaela x Irişca), 8-9 - F_2 BC (Mihaela x Irişca) x Mihaela, 10 – F_2 BC Mihaela x Irişca) x Irişca.

D. 1 – Mihaela, 2 - Dwarf Moneymaker, 3-8 – F_3 (Mihaela x Dwarf Moneymaker), 9-10 – F_2 BC Mihaela x Dwarf Moneymaker) x Mihaela, 11 – F_2 BC (Mihaela x Dwarf Moneymaker) x Dwarf Moneymaker.

Evaluation promising forms under field conditions in respect of productivity revealed a rather high variability of both the total harvest (Figure 3 A) and the share of market fruit (Figure 3 B).The total harvest of the initial forms ranged from 44.9 t / ha (variety Irişca) to 55.2 (variety Dwarf Moneymaker), the rate of market fruit was 87.0 ... 97.0%. The total harvest in hybrid combination F_3 (Maestro x Irishka) and F2 BC (Maestro x Irişca) x Maestro was 53.0 and 55.7 t / ha, much higher than of the parent with high values, variety Maestro (48.2 t / ha). The hybrid combinations F_2 BC (Maestro x Irişca) x Irişca the harvest was at the level of the best parent, and the hybrid combinations where for crosses were used varieties Maestro and Dwarf Moneymaker, lines showed a lower harvest with the exception of the combination F_2BC (Maestro x Dwarf Moneymaker) x Maestro. In combinations derived from crosses of varieties Mihaela and Irisca, Mihaela and Dwarf Moneymaker the total harvest was lower than the best parent except combination F3 (Maeda

x Dwarf Moneymaker) for which the total harvest was much higher than of the parent with high values. After evaluating the market rate of fruit it was found that hybrid combinations showed a variability of 87.8 ... 97.0%. A low market rate of fruit was recorded for the hybrid combinations F_2BC (Mihaela x Irişca) x Mihaela (89,8%).

t/ha



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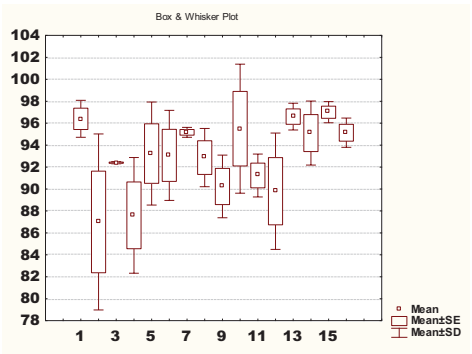

B

Figure 3. Productivity of tomato varieties and lines obtained as a result of intra –specific hybridization, year 2011

1 – Maestro, 2 – Irişca, 3 - Dwarf Moneymaker, 4 – Mihaela, 5 – F_3 (Maestro x Irişca); 6 – F_2 BC (Maestro x Irişca) x Maestro, 7 – F_2 BC (Maestro x Irişca) x Irişca, 8 – F_3 (Maestro x Dwarf Moneymaker), 9 – F_2 BC (Maestro x Dwarf Moneymaker) x Maestro, 10 – F_2 BC (Maestro x Dwarf Moneymaker) x Dwarf Moneymaker, 11 – F_3 (Mihaela x Irişca), 12 – F_2BC (Mihaela x Irişca) x Михаела, 13 – F_2 BC (Mihaela x Irişca) x Irişca, 14 – F_3 (Mihaela x Dwarf Moneymaker), 15 – F_2 BC (Mihaela x Dwarf Moneymaker) x Mihaela, 16 – F_2 BC (Mihaela x Dwarf Moneymaker) x Dwarf Moneymaker

CONCLUSIONS

The highest heat resistance was found in the genotypes of the F_3 generation (Mihaela x Irisca (93.9%) and F_3 Maestro x Irisca (82.9%), and the lowest in the variety Maestro (31.2%).

The genotypes tested showed differential response to heat and can be used later in the research of genetic resistance improvement to high temperatures.

Testing of the selected material based on a character complex, including heat resistance, demonstrated the possibility of creating new tomato forms that combines productivity with resistance to high air temperatures.

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