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Tomato Varieties with High Indices of Productivity and Resistance to Environmental Factors

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ABSTRACT

In this paper, the results of the complex evaluation of valuable morphobiological and agronomic characteristics of tomato varieties, created at the Institute of Genetics and Plant Physiology of the Academy of Sciences are presented. In order to demonstrate the variability of agronomic characters and to specify the value of analyzed genotypes, their comparative evaluation was carried out by some of biological parameters: yield, production rate, average fruit weight, vegetation period, pericarp thickness, resistance to heat and cold stress. The varieties Jubiliar 60/20, Prestij, Elvira, Mihaela, Milenium and Tomiş have determinate growth and are distinguished by plant height, precocity, yield and production. Also, these varieties differ by the important fruit characters as well as mass (large and medium), shape (round, flat-round and cylindrical), the number of lodge (2-3 and above), pericarp thickness (medium and large) and mesocarp thickness (medium, large and extra large). The evaluated varieties manifest increased productivity and good taste properties. The results identify the genotypes that combine precocity, high productivity and resistance to environmental factors. These can serve as initial material for breeding.

Keywords: tomato, breeding, resistance, cold, draught.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops in the world. By degree of use it occupies the second place in the world, being surpassed only by potatoes. Tomato fruits are notable for their taste, dietetic and medicinal properties, as well for divers use (Ershova, 1978; Avdeev, 1982). As per FAO data tomatoes are grown in the world on an area of 4 million ha. The most tomato producing counties are China (974,000 ha) and India (520,000 ha) while Moldova produced 84,070 tons of tomatoes in 2009 (http://faostat.fao.org/).

At the current stage of vegetable development special attention should be paid to qualitative as well as quantitative traits to improve food security of the country. In agrocenosis the increase of crop yields is not only due to optimized growth conditions, but also due to the use of more productive and resistant genotypes.

It has been shown that the role of genotype for both quantitative and qualitative components of yield is higher, when the pedo-climatic and climatic conditions are unfavorable. Expansion of sown fields and plantations occupied by the varieties and hybrids resistant to abiotic and biotic environment extremes substantially reduces harvest losses and production costs. Positive effects can be obtained by using a sufficient number of specially selected genotypes for specific agro-ecological zones and taking into account the considerable variability in growing conditions of the plants. Now we have a critical need - to develop and implement the regional models of species and hybrids, to develop and introduce some detailed “passports” of homologated and of

perspective forms of crops (Kilchevsckiy, 1984, 1987; Juchenco, 1988, 2005; Pivovarov, 1990, 2003).

Contemporary breeding demonstrates the need to create of lines, varieties and hybrids with high environmental resistance. Importance of adaptive breeding in creation of varieties that combine resistance to stress factors with high productivity is recognized by many researchers. (Lapton, 1981; Kilchevsckiy and Hotileva, 1997; Mihnea *et al*. 2002, Iurlova, 2006; Lupashku *et al*. 2008). .Creating of new tomato varieties that will combine the high productivity and ecological resistance has one of the priority directions of contemporary breeding. (Lapton, 1981; Mihnea *et al*., 2002; Lupashku *et al*. 2008)**.**

Development of new varieties and hybrids that are high yielding ,possessing better fruit quality and longer shelf life, resistant to biotic and abiotic stress and are able to provide high harvests under the conditions of positive low temperature (2-3^{0}C) and of low light is worthwhile an indispensable component of solving a global problem of creating more economic technologies in terms of bioenergetics. That is why, today, in order to create new forms of tomato breeders have to consider the whole complex characters especially the productivity, fruit quality, the resistance to abiotic (including climate change) and biotic stresses.

For achieving such objectives, breeding activities were carried out during the period 1995-2011 in the Institute of Genetics, Physiology and Plant Protection to obtain new lines and varieties of tomatoes, which satisfy the requirements of precocity, productivity, resistance to temperature fluctuations and quality. This paper focuses on recently developed tomato varieties in our institute.

Material and methods

The experiments were performed under field condition, on the experimental areas of the Institute of Genetics and Plant Physiology and in the Lab of Applied Genetics. Experimental materials consisted of six tomato varieties obtained through intraspecific and interspecific crosses: Mihaela, Elvira, Jubiliar 60/20, Prestij, Milenium and Tomiş along with two control varieties Soiearis and Peto 95.

Field experiments were conducted in 3 repetitions, in randomized blocks with the distance between rows - 70 cm and between plants - 30 cm. During the vegetative period phonological observations were made. Morphological description was done according to "Guidelines on the testing of vegetable and root crops", Baculina V.A, *et al*. (1982), and "Guidelines for the conduct of tests for distinctness, uniformity and stability" (1992). The scale of resistance to cold temperature was measured following VIR method (Ivackin, 1979).

For assessing the tomato genotypes by sporofit resistance at high temperatures methodological recommendations the VIR were used based on plant growth capacity maintained at high temperatures during 6 hours (Smirnova and Garanko, 1990) . Statistical analysis was performed as described by Dospehov, (1979).

Results and discussions

Morphological description of observations revealed that five varieties of tomato have the determinate type of growth and only the Prestij variety is semi-determinate. The plants are medium branched (Mihaela, Prestij and Tomiş varieties have 5-6 branches and 3-5 branches the rest). By plant height the varieties were placed as follows: Elvira, Jubiliar 60/20, Milenium - 40.0 to 50.0cm, Mihaela, Tomiş - 50,0-60.0cm and the variety Prestige - 65.0 - 70.0 cm.

For all studied varieties the leaf is standard, low and intermediate corrugated, sectate in large, medium and small segments, dark green color of leaf for Millennium and Tomiş varieties, green for Prestij and green-gray to the rest of varieties.

Flowers are regular, yellow colored, inflorescence is simple, 3-5 flowers for Jubiliar 60/20, 5-6 flowers - Elvira, Prestij and Tomiş, and 6-8 flowers - Mihaela and Milenium. The first inflorescence usually appears after the 5-6 node, the following-after 1-2.

The main differences were tested by productivity, fruit quality and fruit main characters. By the fruit form they can be divided into the following groups: 1- circular (Elvira, Mihaela, Milenium and Tomiş), 2- slightly flattened (Prestij), 3- cylindrical (Jubiliar 60/20). Fruits on cultivar Jubilee 60/20 are little edge, at the rest the fruits is smooth.

By fruit mass, the majority of varieties have large fruits (105,0…130,0g), only two varieties (Mihaela and Milenium) have medium fruits (71,7…95,0g). In breeding a high attention is given to thickness of mezocarp. The size of mezocarp determines the destination of fruit (fresh use, juice or paste). According to existing standard, tomato fruits are divided into five groups by the named index: very small (2,0 cm), small (2,1 to 3,0 cm), medium (3, 1 to 4,0 cm), large (4,1 to 5,0 cm), very large (> 5 cm). By this character, the pulp at varieties Jubiliar 60/20, Mihaela, Milenium and Tomiş is medium, and the Prestij and Elvira - is large.

Pericarp thickness represents an important indicator that influence market yields. Data from the specialized literature (Bakulina, 1970; Blashiuk, 1983; Kuzeomensckiy, 2004; Mihnea, 2008) provide evidence for a considerable genotypic variability of the mentioned trait. The studied varieties were assessed in terms of pericarp size and significant differences were ascertained (Table 1). According to the existing standards of tomato morphological traits, pericarp can be: thin (<3 mm), average (3-6 mm), and thick (>6 mm). Based on the comparative analysis of the results, tomato varieties were divided into two groups: with thick pericarp (Jubiliar 60/20, Mihaela, Prestij), with pericarp of medium thickness (Elvira, Milenium and Tomiş). Therefore, varieties created in IGFP, along with other valuable character, also possess carrying capacity of fruits.

Number of seminal lodge represents an internal morphological character of the sinecarpelar fruit based on which the number of overgrown carpels is determined that forms the pistil and type of placenta. Usually, in tomatoes the number of cameras ranges from 2-3 to 5-9. Large fruits have a large number of lodges, the medium-sized have a smaller number. Numbers of seminal lodges differ from one variety to another. Depending on this aspect two types of fruits were found: with 2-3 seminal lodges (Prestige, Jubiliar 60/20, Mihaela, Milenium) and with 3 ... 5 seminal lodges (Elvira, Tomiş).

It is known that no matter in what direction the breeding is carried out, the specialists firstly draw attention to precocity, yield and fruit quality. Vegetation period is an index that determines the biological precocity of tomato, the possibility to cultivate in certain areas. According to the literature it is related to productivity, resistance to cold, chemical composition, resistance to pests and diseases (Ershova, 1978; Avdeev, 1982). Phonological observations made during the vegetation period showed significant differences on the growing season, depending on variety and climatic conditions. Based on the vegetation period, tomatoes are classified in: ultra-early (<105 days), early (106-110 days), medium (111-115 days), late (116- 120 days) and very late (> 120 days).. As a result of the investigations a high diversity of varieties in the basis of vegetation period was found.

The varieties created in our institute can be classified in four groups: very early (Tomis, Milenium), early (Elvira), medium early (Mihaela, Prestij), late (Jubiliar 60/20).

In order to determine the role of the genotype factor, year and interaction of genotype and year, for overall productivity and fruit quota of product - culture the factor analysis was done (Table 2, 3).

The data showed that in the case of tomato cultivation by seedling, conditions of the year had a higher share than the genotype - 76, 23 and 50,29%, respectively, for general productivity and fruit quota. Role of genotype was more important in the case of the second clue (28,66%), than in the case of overall productivity (16,42%). The share sum of genotype (28,66%) and its interaction with the environment (7.98%) reveal their quite high role (36,64%) in the obtaining quality production.

Role of genotype factor is also demonstrated by the differential reaction of varieties to the year conditions and according to the character. For example, in the case of overall productivity, the Mihaela variety presented the most stable indices (56,6-59,7t/ha), and Jubiliar variety – the most variable (42,0-72,3 t/ha) (Fig. 1 A).

Regarding the market fruit quota, it was noticed a reduced variability at Prestij variety (80,8-82,6%) and Solearis variety (79,5-82,0%), but quite high at Elvira variety (78,8-87,1%) (Fig 1 B).

In comparison to the plants cultivated by seedling, to those cultivated from seeds the role of genotype is increased significantly (48,93%) for the overall productivity, and for the market fruit quota has increased a lot the share of genotype vs year interaction factor (44,61%) (Table 3).

The data presented reveal that by this method of cultivation the tomatoes achieve more definitive genetic potential of plants, especially regarding their capacity of interaction with the environment. For example, in the case of overall productivity, variety Milenium presented a smaller variation (46,4-60,1t/ha) (Fig.2 A), and in the case of fruit quota – Tomis variety (89,4-94,5%) (Fig. 2 B).

Peto 95 variety demonstrated very large limits (81,4-91,8%), which makes difficult the character forecasting.

Especially attention was attracted by the varieties: Tomis (Fig. 3) Mihaela (Fig. 4), Jubiliar 60/20 (Fig. 5) which achieved very significant production in 2008 and 2009 years.

Evaluation of tomato resistance to heat and drought (Fig. 6), indicates that all varieties show a high resistance to cold and medium resistance to heat (Elvira, Jubiliar 60/20, Prestij, Tomis). Increased heat resistance indices were registered for the varieties Milenium and Mihaela, resistance that was 73.1% and 64.7% respectively.

The chemical composition of fruits among the studied varieties (Table 4) (in comparative culture

competition) shows the quality value of fruit. Thus created varieties differ from control by all biochemical indicators. It should be mentioned that all varieties exceeded the standard by index sugar / acidity, which is an indicator of fruit quality. This shows that created varieties manifested only increased productivity, but high taste properties also.

Conclusions

The varieties created at Institute of Genetics, Physiology and Plant Protection: Jubiliar 60/20, Elvira, Mihaela, Milenium, Tomis are determinate while Prestij is semi-determinate, medium leafy and branched. They differ by plant height, fruit size, precocity, total and market yields. Also, they are distinguished by a complex of fruit characters: fruit mass (large and medium), shape (round, slightly-flatbed and cylindrical), the number of loge (2-3 and more), thickness of pericarp (medium and thick), and thickness of mezocarp (medium, large and very large).

Created varieties show increased productivity and high taste properties, high resistance to cold and heat. They can be recommended for use in breeding programmer to create new varieties.

Table 1. Comparative analysis of tomato varieties after a complex morphological character

Variety	Fruit weight, g	Fruit form	Number of seminal lodge	Pericarp thickness, mm.	Mezocarp thickness, cm
Jubiliar 60/20	105.0±8,17	cylindrical	2.8±0,13	8.6±0,22	3.8±0,62
Prestij	120.0±10,9	slightly flattened	3.0±0,01	7.6±0,37	4.4±1,62
Elvira	130.0±5,93	circular	4.5±0,37	5.4±0,26	4.6±1,59
Mihaela	95.0±3,24	circular	2.6±0,16	8.0±0,21	3.8±0,93
Milenium	71.7±3,50	circular	2.4±0,18	3.0±0,31	3.9±0,84
Tomiş	102.0±3,00	circular	3.7±0,15	5.8±0,27	4.2±0,96
Solearis (martor)	110.0±7,55	slightly flattened	4.3±0,33	5.4±0,22	4.8±1,59

Table 2. Factor analysis of the source of variation of productivity and fruit quota of tomatoes growing by seedling

Source of variation	Degree of freedom	Squares sum of effects	Share in source of variation, %
	General productivity		
Tomato genotype	4	208.4*	16.42
Year	2	967.4*	76.23
Genotype x year interaction	8	79.8*	6.29
Aleatory effects	30	13.5	1.06
	Quota of market fruits		
Tomato genotype	4	38.8*	28.66
Year	2	68.1*	50.29
Genotype x year interaction	8	10.8	7.98
Aleatory effects	30	17.7	13.7

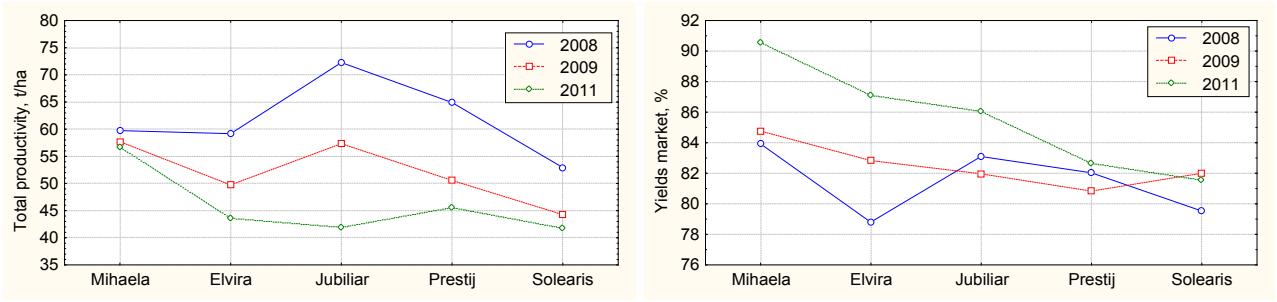
* - p≤0,05

Table 3. Factor analysis of the source of variation of productivity and market fruit quota of tomatoes growing by seeds

Source of variation	Degree of freedom	Squares sum of effects	Share in source of variation, %
	General productivity		
Genotip de tomate	2	389.79*	48.93
An	3	337.55*	42.37
Interacţiune genotip x an	6	63.06*	7.91
Efecte aleatorii	24	6.29	0.9
	Quota of market fruits		
Genotip de tomate	2	30.4*	29.54
An	3	19.3	18.76
Interacţiune genotip x an	6	45.9*	44.61
Efecte aleatorii	24	7.3	7.09

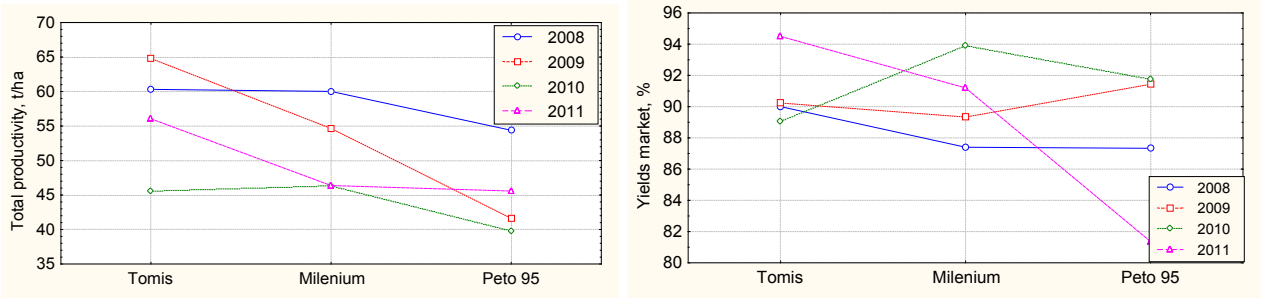
*- p≤0,05

Fig.1. Influence of the year conditions on the overall productivity (A) and market fruit quota (B) of tomatoes cultivated by seedling



A **B**

Fig.2. The influence of year conditions on overall productivity (A) and fruit quota (B) at tomatoes cultivated by seeds



A **B**

Figure 3. Variety early Tomiş

Figure 4. Variety medium early Mihaela

Figure 5. Variety medium late Jubiliar 60/20

Figure 6. Evaluation of tomato varieties for resistance to cold and drought
1. Jubiliar 60/20 2. Prestij 3. Elvira 4. Mihaela 5. Milenium 6. Tomiş 7. Solearis (standard)

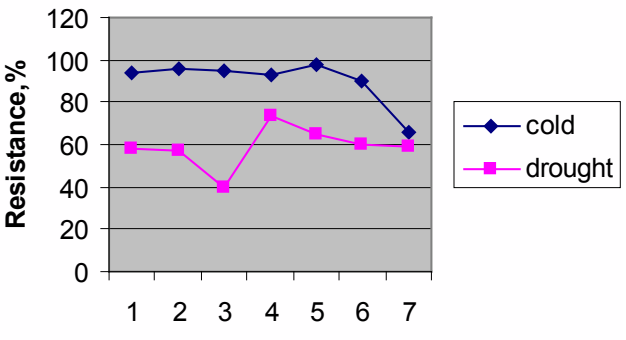


Table 4. Chemical composition of tomato fruits

Variety	Dry matter %	Sugar %	Vitamin C, мг/%	Acidity %	Sugar/acidity indice
Jubiliar 60/20	5.5	5.4	46.0	0.50	10.8
Prestij	6.2	5.5	52.0	0.78	7.1
Elvira	6.0	5.4	47.6	0.66	8.2
Mihaela	6.0	4.5	35.2	0.58	7.8
Milenium	6.0	4.5	35.2	0.58	7.8
Tomiş	5.2	4.3	27.3	0.50	8.6
Solearis (standard)	5.7	5.0	52.0	0.80	6.6

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