

AGRONOMIC EVALUATION OF TOMATO HYBRIDS FOR GLASS-HOUSE PRODUCTION

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Abstract

The tomato is the most widely cultivated vegetable crop, both in glasshouses and walk-in tunnels. The objective of the trial is to make a recommendation for tomato hybrids intended for protected crops production in the Republic of Macedonia. It was carried out in the region of Sv. Nikole (Central Macedonia) in glasshouses. The following newly introduced tomato hybrids, made by four different producers, have been examined: Fito - *Meriva* F₁, Enza Zaden - *Lezoforta* F₁ and *Amaneta* F₁, Syngenta - *Zouk* F₁, Clause - *Loreli* F₁. The applied experimental design was a randomized block system in five replications. Aside from the dynamics of germination, flowering, and ripening and harvesting, the productive traits of each hybrid were analyzed using ANOVA. It was confirmed that the hybrids *Zouk* F₁ and *Loreli* F₁ had the earliest germination and the latest germination was exhibited by the *Amaneta* F₁. The shortest period between germination and flowering was recorded in the hybrid *Loreli* F₁, and the longest in *Lezoforte* F₁. The period between flowering and fruit ripening was shortest in the hybrid *Zouk* F₁, and the longest one in *Amaneta* F₁. The shortest period starting from germination to the beginning of ripening was recorded in the hybrid *Amaneta* F₁ and the longest in *Zouk* F₁. In reference to the productive traits, it was recorded that the largest number of flowers per cluster had the hybrid *Loreli* F₁. The hybrid *Loreli* F₁ exhibited the largest percentage of fruit sets. The lowest percentage of fruit sets per plant was found in the hybrid *Lezoforta* F₁. The largest average fruit mass was observed in the hybrid *Meriva* F₁. The largest yield per plant was recorded in the tomato hybrid *Meriva* F₁. Finally, the highest yield was recorded in the hybrid *Meriva* F₁(173,73 t/ha).

Keywords: protected crops, vegetable production, yield.

Introduction

The tomato (*Lycopersicon esculentum* Mill.) is the leading vegetable crop in the country and in the world. In the production structure in the EU the tomato accounted for 25% while in The Republic of Macedonia it accounted for three percent less (Lazic et al., 2007). For its production in protected houses it is necessary to gain knowledge derived from experience and research on morphology, biology and production technology. On the market there are many different varieties and hybrids of tomatoes. In The Republic of Macedonia, according to the studies of Bogevska et al. (2010), there are 150 recognized varieties of which 126 are foreign, 18 are local and 6 are newly created domestic varieties (Trejsi, 1997, Joldzhik, 1997, Ace, 2001, Asmara, 2001, Longina, 2004, Laguna, 2004), while the number of indigenous landraces is 156. In the area belonging to The Republic of Croatia, 31 varieties of tomatoes had been recognized during the period between 1997 and 2000, of which 17 proved suitable for greenhouse production and outdoors production (Borošić et al., 2001). Milutinović and Đukić (1996) studied 12 varieties of tomatoes. The highest yield were achieved by the hybrids *luna* (67t/ha) and *kazanova* (61t/ha). The largest number of fruits per plant was realized in the hybrid *luna*, 5 fruits per flower cluster, while the highest weight of the fruit of 240 g was achieved in the hybrid *kazanova*. Hybrids *luna*, *lido*, *kazanova*, and the *narvik* variety were recommended for production. Demirovska et al.(1990) examined the yield of five varieties of tomato grown in plastic tunnels intended for autumn production in two production years: 1986 to 1987. The examined varieties were as follows: luka F₁ reference hybrid, balka F₁, duple F₁, caramelo F₁ and

ruders Sk. The highest average yield per plant gave balka F₁ - 1,48 kg, then the variety luka F₁-1,23 kg following the variety duple F₁ - 1,01 kg. The total yield was highest in variety balka F₁ - 54,64t/ha followed by the variety luca F₁ - 46,85 t/ha and the variety duple F₁ 37,10 t/ha which is expected for this kind of production. Jankulovski et al. (2002) examined new tomato hybrids for greenhouse production over a period of two years: Sinatra F₁, Alcludia F₁, Gessa F₁, Ibiya F₁ and Q-75-48 F₁. These varieties were compared to the leading variety for greenhouse production, Marfa F₁. During the vegetation several parameters were examined: the vegetation period from sprouting to first harvest, percentage of fertilization, characteristics of the fruit, total yield and index of earliness. Based on the analyzed parameters authors recommended hybrids Gessa F₁, Sinatra F₁ and Alcludia F₁. Ibraim (2012) characterized 14 indigenous tomato landraces originating from other regions in Macedonia grown on various altitudes. Regarding the length of the vegetation period 5 landraces were characterized by a relatively short period of 103-105 days, while the other 9 have a longer vegetation period of up to 115 days. In terms of morphological characteristics, there were very significant differences in the tested landraces. For example, fruit weight ranged from 119 g in landrace 1 to 225 g in landrace 5. In reference to production traits the author stated that the yields achieved per plant and per hectare differ significantly in terms of the average of all tested landraces. In 7 landraces the yield is lower, while in the other 7 the yield increased from 24 to 27%. With many varieties and hybrids producers are asking themselves which ones are suitable for production. This means that the choice depends on the necessary information available for morphological, biological and most importantly, the production features. Hence, the aim of this research is to study the advantages and potentials of several tomato hybrids in glasshouse production through comparative study of biological, morphological and commercial properties. The differences in the results of the survey will be used for identification and recommendation of these hybrids that will guarantee stable production in glasshouses in Sveti Nikole.

Material and methods

In order to achieve the objective, according to the methodology, research was done in 2012 on 5 tomato hybrids from four seed companies (Fito -Meriva F₁, Enza Zaden - Lezoforta F₁, Amaneta F₁, Syngenta - Zouk F₁, Clause- Loreli F₁). Meriva F₁ is an indeterminate medium-early maturing tomato hybrid intended for production in protected houses. The stem is robust with vigorous leaf mass and a well-developed root system. The fruits are large, weighing 200-220 g, spherical in shape, slightly flattened, with good toughness. The fruit is red. Resistant to diseases Verticillium, Fusarium, Tobacco mosaic virus and Cladosporium. Lezoforta F₁ is a medium-early maturing tomato hybrid used for protected houses as the first crop. The stem is robust with vigorous leaf mass and a well-developed root system. Fruits are round, slightly elongated in size and weigh from 200 to 220 g. The color is dark red. Resistant to diseases Verticillium, Fusarium, Tobacco mosaic virus and Cladosporium. Amaneta F₁ is an early indeterminate tomato hybrid intended for production in protected houses as the first crop. The stem is robust with strong leaf mass and strongly developed root system. The fruits are round, slightly flattened with a size of 220-250 g. The color of the fruit is dark red. Resistant to diseases Verticillium, Fusarium, Tobacco mosaic virus and Cladosporium. Zouk F₁ is an early indeterminate hybrid with high production potential. It can be grown throughout the year. The stem is robust with strong leaf mass and a strongly developed root system. Fruits are round, dark red with short sepal. The fruit size is 170-180 g, it is resistant to cracking and the following diseases: Verticillium, Fusarium, Tobacco mosaic virus and Cladosporium. Loreli F₁ is an early indeterminate tomato hybrid intended for production in protected houses as well as in the open field. The plant is robust with strong leaf mass and a strongly developed root system compared to the other hybrids of the breeding company Clause. It is recommended to be grown as the first crop, because it is characterized by high tolerance to changing production conditions. The fruits are arranged in the form of a fish bone, weighing 180-220 g with a beautiful red color and excellent flavor properties. It is resistant to the following diseases: Verticillium, Fusarium, Tobacco mosaic virus and Cladosporium. The hybrids were tested in glasshouses in Sveti Nikole, where there are favorable conditions for

cultivation. The experiment was set by a method of randomized blocks with five repetitions. In order to perform characterization during the vegetation more biological and morphological parameters were analyzed. The technology of production was common for tomato growing. Hybrids were grown with previous production of seedlings. During the vegetation period the following phenological stages of growth were registered: days from sowing to sprouting, days from sprouting to flowering, days from flowering to early maturing, growing season (vegetation period) in order to determine the earliness of examined hybrids. Morphological characteristics were observed through the following parameters: number of leaves to the first flower branch, length of internodes and number of leaves between flowering branches, number of flowers per flower cluster, number of fruits per cluster, fruit shape, fruit mass, length of the peduncle, thickness of pericarp, cracking of tomato fruit, outbreak of cat face, number of chambers in the fruit, the color of the fruit. The number and weight of fruits per plant, yield per unit area, dynamics of yield per harvests contributed to obtain fertility of hybrids or to evaluate production properties. During the vegetation period, standard technology of tomato production in glasshouses was applied. The obtained results from examined parameters were statistically processed by calculating the mean value, standard deviation, coefficient of variation, error of the mean value. The yield and yield components were statistically processed by analysis of variance (ANOVA) and LSD test at the level of 0,05 and 0,01.

Results and discussion

In Table 1, stages of growth in days are shown. The number of days from sowing to sprouting ranged from 5 to 7 days, where the hybrid Amaneta F₁ germinated last for 7 days, compared to hybrids Zouk F₁ and Loreli F₁, who sprouted for 5 days. Unlike sprouting, the hybrid Amaneta F₁ flourished first for 81 days, while the hybrid Lezoforta F₁ flourished last for 88 days. In this survey days from flowering to ripening ranged from 46 to 65 days. The shortest time from flowering to ripening had the hybrid Zouk F₁ (46 days), unlike hybrid Amaneta F₁ which began ripening for 65 days.

Table 1. Stage of growth in days

Hybrid	Date of sowing	Date of transplanting	Days from sowing to sprouting	Days from sprouting to flowering	Days from flowering to ripening	Vegetation period
MerivaF ₁	03.12.2011	24.02.2012	6	86	47	133
Lezoforta F ₁	03.12.2011	24.02.2012	6	88	54	142
Amaneta F ₁	03.12.2011	24.02.2012	7	81	65	146
ZoukF ₁	05.12.2011	24.02.2012	5	85	46	131
Loreli F ₁	08.12.2011	24.02.2012	5	83	49	132

The vegetation period for all hybrids ranges from 131 to 146 days where the hybrid Zouk F₁ had the shortest vegetation period (131 days), compared to the hybrid Amaneta F₁ where vegetation period was 146 days. Hybrids Meriva F₁ and Loreli F₁ very much alike to Zouk F₁, had the shortest period of 133 days and 132 days respectively, unlike the hybrid Lezoforta F₁ which had 142 days. Together with the hybrid Amaneta F₁, it belongs to hybrids with the longest growing season. The characteristics of the whole plant and the fruit of the tested hybrids are given in Table 2.

Table 2. Characteristic of plant and fruit

Hybrid	Number of leaves to first flower cluster	Length between nodes (cm)	Number of leaves between flower cluster	Fruit shape	Cracking Yes/No	Cat face	Number of locular cavity	Fruit color
Meriva F ₁	6	21	3	round to slightly flattened	No	no	6	red
Lezoforta F ₁	6	17	3	round to slightly elongated	No	no	7	red
Amaneta F ₁	7	20	3	round to slightly flattened	No	no	5	red
Zouk F ₁	6	15	3	round	No	no	6	red
Loreli F ₁	7	18	3	round	No	no	7	red

According to the measured parameters, the number of leaves to the first flower branch for all hybrids is similar. Hybrids Amaneta F₁ and Loreli F₁ (7) had the highest number of leaves, while the lowest number was registered in hybrids Meriva F₁, Lezoforta F₁ and Zouk F₁ (6). Length between nodes (flower branch) ranged from 21cm in hybrid Meriva F₁ to 15 cm in hybrid Zouk F₁. The number of leaves between flower clusters is the same in all examined hybrids (3). The shape of the fruit is round to slightly flattened in hybrids Meriva F₁ and Amaneta F₁, round to slightly elongated in hybrid Lezoforta F₁ and round in hybrids Zouk F₁ and Loreli F₁. Cracking as common phenomena depends on the specifics of the hybrid and the conditions and method of cultivation. In this research cracking was not expressed in tested hybrids. Also, there is no appearance of a high degree of deformity of the fruit commonly known as cat face in examined hybrids. The number of locular cavity as part of the fruit structure ranges from 5 in Amaneta F₁ to 7 in LezofortaF₁ and Loreli F₁. Fruit color in all tested tomato hybrids was red.

Table 3. Number of flowers in cluster

Hybrid	Meriva F ₁	Lezoforta F ₁	Amaneta F ₁	Zouk F ₁	Loreli F ₁
Repetition I	5,1	4,4	5,4	5,1	5,8
II	5,6	4,8	5,4	4,6	5,6
III	5,4	4,8	5,5	4,5	6,1
IV	5,2	4,7	5,4	4,5	6,0
V	5,2	4,6	5,4	4,5	5,9
Mean	5,3	4,7	5,4	4,6	5,9
STDEV	0,21	0,18	0,04	0,25	0,22
CV	3,91	3,91	0,78	5,41	3,68
sx	0,09	0,08	0,02	0,11	0,10

The average number of formed flowers of five hybrids ranges from 4,6 to 5,9, where the largest number of flowers had Loreli F₁(5,9) while the lowest number of formed flowers in a flower cluster had Zouk F₁ (4,6) (Table 3). In the research of Lekshmi and Celine (2015) the number of flowers per cluster in different tomato hybrids was from 5,65 to 7,16 which is higher in comparison to our findings. The coefficient of variation was calculated. The lowest coefficient of variation was observed in Amaneta F₁ (0,78%) while the highest was recorded in Zouk F₁ (5,41%). More important in the analysis of hybrid traits is the number of fertilized flowers. The number of fertilized flowers is presented in Table 4.

Table 4. Number of fertilized flowers in flower cluster

Hybrid		MerivaF ₁	LezofortaF ₁	AmanetaF ₁	ZoukF ₁	LoreliF ₁
Repetition	I	4,1	4,2	4,3	4,6	5,1
	II	4,9	4,3	4,8	4,2	5,3
	III	4,9	4,0	4,8	4,2	5,4
	IV	4,8	4,2	4,4	4,3	5,6
	V	4,7	4,1	4,9	4,2	5,4
Mean		4,7	4,2	4,6	4,3	5,4
sx		0,15	0,05	0,12	0,08	0,09
STDEV		0,33	0,12	0,26	0,18	0,21
CV		7,17	2,82	5,63	4,16	3,84
LSD	0,05	0,32				
	0,01	0,44				

The analysis of the number of fertilized flowers (Table 4) showed that the highest average number of fertilized flowers had the hybrid Loreli F₁ (5,4), while the hybrid Lezoforta F₁ had lowest number of fertilized flowers (4,2). Concerning the coefficient of variation the highest coefficient was determined in the hybrid Meriva F₁ (7,17%) while the lowest in the hybrid Lezoforta F₁ (2,82%)

Table 5. Fruit mass (g)

Hybrid		Meriva F ₁	Lezoforta F ₁	Amaneta F ₁	Zouk F ₁	Loreli F ₁
Repetition	I	261,0	227,0	252,0	182,0	216,0
	II	241,0	206,0	229,0	196,0	209,0
	III	237,0	226,0	225,0	207,0	209,0
	IV	245,0	225,0	249,0	181,0	188,0
	V	256,0	221,0	220,0	209,0	203,0
Mean		248,0	221,0	235,0	195,0	205,0
STDEV		10,2	8,7	14,5	13,3	10,6
CV		4,1	3,9	6,2	6,8	5,5
sx		4,5	3,9	6,5	5,9	4,7

The mass of the fruit ranged from 195g in Zouk F₁ to 248g in Meriva F₁. According to the coefficient of variation the highest value had the hybrid Zouk F₁ (6,8%) while the lowest hybrid Lezoforta (3,9%). The coefficient of variation showed that fruits of the hybrid Lezoforta F₁ were more uniform by weight. The mass of fruit is given in Table 5. The mass of the flower cluster was highest in Meriva F₁ (1158 g), while the lowest mass of flower cluster was determined in Zouk F₁ (837 g). The lowest value of the coefficient of variation was calculated in Amaneta F₁ (0,88%) while the highest was recorded for Zouk F₁ (4,77%). The mass of one flower cluster is shown in Table 6. The lowest yield per plant of 6 flowering clusters was obtained in Zouk F₁ (5,02 kg), while the highest yield was achieved by Meriva F₁ (6,95kg). The coefficient of variation was lowest in hybrid Amaneta F₁ (0,88%), while highest in hybrid Zouk F₁ (4,77%). One important parameter of all tested hybrids is the obtain yield per unit area. The yield of this survey is calculated by the usual production structure within the 25,000 plants, which confirmed the results obtained in the optimal range for the tested hybrids. Values of yields for one year research are presented in Table 8. The yield in tested hybrids ranged from 125,6t/ha in hybrid Zouk F₁ to 173,7 t/ha in hybrid Meriva F₁. The lowest coefficient of variation was determined in hybrid Amaneta F₁ (0,9%) while the highest was determined in hybrid Zouk F₁ (4,8%). Shrestha and Sah (2014) made an evaluation of tomato cultivars for Central Tarai of Nepal. Results showed that cv. HRDTOM-005XHRDTOM-010 (30.64 t/ha) followed by Makis (28.90 t/ha) and cv. Srijana (28.87 t/ha) gave higher yield among the tested cultivars which does not correspond with our findings.

Table 6. Mass of one flower cluster (g)

Hybrid		MerivaF ₁	LezofortaF ₁	AmanetaF ₁	ZoukF ₁	LoreliF ₁
Repetition	I	1070,0	953,0	1084,0	837,0	1102,0
	II	1181,0	886,0	1099,0	823,0	1108,0
	III	1161,0	904,0	1080,0	869,0	1129,0
	IV	1176,0	945,0	1096,0	778,0	1053,0
	V	1203,0	947,0	1078,0	878,0	1096,0
Mean		1158,2	927,0	1087,4	837,0	1097,6
STDEV		51,55	30,04	9,53	39,94	27,86
CV		4,45	3,24	0,88	4,77	2,54
sx		23,06	13,44	4,26	17,86	12,46

Table 7. Yield per plant from 6 flower clusters (kg)

Hybrid		MerivaF ₁	LezofortaF ₁	AmanetaF ₁	ZoukF ₁	LoreliF ₁
Repetition	I	6,420	5,718	6,504	5,022	6,612
	II	7,086	5,316	6,594	4,938	6,648
	III	6,966	5,424	6,480	5,214	6,778
	IV	7,056	5,670	6,576	4,668	6,318
	V	7,218	5,682	6,468	5,268	6,576
Mean		6,95	5,56	6,52	5,02	6,59
STDEV		0,31	0,18	0,06	0,24	0,17
CV		4,45	3,24	0,88	4,77	2,56
sx		0,14	0,08	0,03	0,11	0,08
LSD	0,05				0,29	
	0,01				0,40	

Table 8. Yields in t/ha

Hybrid		Meriva F ₁	Lezoforta F ₁	Amaneta F ₁	Zouk F ₁	Loreli F ₁
Repetition	I	160,50	142,95	162,60	125,55	165,30
	II	177,15	132,90	164,85	123,45	166,20
	III	174,15	135,60	162,00	130,35	169,35
	IV	176,40	141,75	164,40	116,70	164,40
	V	180,45	142,50	161,70	131,70	164,65
Mean		173,7	139,1	163,1	125,6	165,98
STDEV		7,7	4,6	1,4	6,0	2,0
CV		4,6	3,3	0,9	4,8	1,2
Sx		3,5	2,1	0,6	2,7	0,9
LSD	0,05				6,9	
	0,01				9,5	

Conclusions

Taking into consideration all examined traits, the hybrids Meriva F₁, Loreli F₁ and Amaneta F₁ can be recommended for production in glasshouses.

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