

The Evaluation of Yield Potential and Quality of Fruits at Tomato Hybrids Cultivated in Greenhouse

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Abstract. The selection of hybrids with good yield potential has great importance in greenhouse tomatoes culture in order to improve the economic efficiency of this crop. Consumer interest in the quality of vegetable products also increased in the last years. In this experiment six tomato hybrids for fresh consumption recommended for greenhouse culture were evaluated as yield potential and quality of fruits. The evaluation of tomato fruits quality included appearance, firmness and chemical composition. The highest early and total yields were obtained in Menhir F₁, Shanon F₁ and Monroe F₁ and the best fruit quality in Monroe F₁, Tolstoi F₁ and Cronos F₁.

Keywords: tomato hybrids, greenhouse, yield, fruit quality

INTRODUCTION

Indoor production for fresh vegetables offers advantages compared to outdoor production with regard to quality assurance principally, because the products are not exposed directly to the rapid changes of climate conditions (Gruda, 2005). Greenhouse culture may be an alternative to the outdoor culture for high-value vegetable crops, including tomatoes, in actual climatic changes. An important role in the profitableness of this culture is played by using of some tomato hybrids with a big yield potential and a good quality of fruits. Alongside trade liberalization in the EU countries, Romanian vegetable growers have to compete with the other European vegetable growers. In these conditions, in order to obtain profitable yields, Romanian farmers need as many and as exact as possible information concerning the yield potential and the quality of fruits of tomato hybrids which are sold on the seed markets.

MATERIALS AND METHODS

The research performed in the greenhouse of UASVM Cluj-Napoca in 2009 was organized as a mono-factorial experience, the experimental factor being represented by hybrid. Six tomato hybrids (Monroe F₁, Marissa F₁, Tolstoi F₁, Cronos F₁, Menhir F₁ and Shanon F₁) laid out in soil culture in greenhouse were evaluated as yield potential and quality of fruits. The experimental design was randomized blocks, replicated three times. The planting of transplants in soil was done at the end of January. Planting density was 31.250 per hectare. Usual technology for Ist cycle tomatoes culture was applied. Fruits were harvested at the appearance of red color in gel and pericarp tissue (M-4 maturity stage, by Kader, 2002). Observations concerning quantity and quality of yield at each harvest were done. Commercial quality of fruits was established by weighing of each harvest on three categories of fruits: extra (>100 g), first quality (50-100 g) and second quality (<50 g). Ten fruits per plot were

analyzed, evaluating the following characteristics: weight, shape and firmness – as external quality traits, as well as soluble solids content, total sugar, titratable acidity and ascorbic acid concentration – as internal quality traits. Observations concerning growth and fructification of plants were done before the beginning of harvesting and they were repeated once during fructification period.

RESULTS AND DISCUSSION

The hybrids utilized in the experiment were of medium to strong vigor with good growth, flowering and fructification. Concerning the height of plants there were not recorded significant differences between hybrids all of them having a vigorous growth. Cronos F₁ recorded the highest number of leaves which means the shortest internodes and a high number of inflorescences (8.67). The mean number of fruits in the first seven inflorescences varied between 4.93 at Marissa F₁ and 7.60 at Tolstoi F₁ (Tab.1).

Fruit harvesting was started in the second decade of April and it was finished in the second decade of July. Early yield was considered being that one harvested till 31 of May. The analysis of variance (Tab. 2) shows very significant early yield increases for Menhir F₁ and Shanon F₁ and very significant yield decreases for Monroe F₁, Tolstoi F₁ and Cronos F₁ in comparison with control (mean of the experiment).

Tab. 1

Growing and fructification features of six tomato hybrids cultivated in greenhouse

Hybrid	Plant height (cm)	Number of leaves	Number of inflorescences	Mean number of fruits in the first seven inflorescences
Monroe F ₁	248.33	32.00	7.67	5.60
Marissa F ₁	231.67	31.33	9.00	4.93 ⁰⁰⁰
Tolstoi F ₁	245.00	33.00	8.00	7.60***
Cronos F ₁	238.33	36.00**	8.67	6.40
Menhir F ₁	243.33	31.67	7.00	5.63
Shanon F ₁	241.67	31.67	7.67	6.13
Mean of the experiment (control)	241.39	32.61	8.00	6.05
LSD 5%	11.60	1.90	1.37	0.49
LSD 1%	16.48	2.70	1.95	0.70
LSD 0.1%	23.87	3.91	2.82	1.01

The results obtained for early yield were confirmed in case of total yield for Menhir F₁ and Shanon F₁ with the highest yield increases and by Tolstoi F₁ and Cronos F₁ with the very significant yield decreases in comparison with the mean of the experiment. Unlike the early yield, Monroe F₁ had a very significant total yield increase in comparison with control. It can be also remarked that most of the hybrids recorded total yields over 11 kg/m².

The proportion of extra and first quality fruits from the total yield varied between 87.31% at Cronos F₁ and 94.44% at Shanon F₁ (Tab. 3). With the highest proportions of extra and first quality fruits from the total yields Marissa F₁, Monroe F₁, Mehnr F₁ and Shanon F₁ were remarked. The same hybrids recorded the highest proportions of extra and first quality fruits when reported to the control.

Tomato fruits quality was assessed by physical and chemical features. The main physical characteristics of tomato hybrids, followed in the experiment, are presented in table 4. The mean weight of fruits varied between 88.20 g at Cronos F₁ (very significant decrease in comparison with control) and 130.7 g at Monroe F₁ (very significant increase in comparison

with control). According to the U.S. Standards for grades of fresh tomatoes (1991), as diameter, the fruits of Marissa F₁, Tolstoi F₁ and Cronos F₁ are sized as small (5.40-5.72 cm), the fruits of Menhir F₁ and Shanon F₁ as medium (5.72-6.35 cm) and the fruits of Monroe F₁ as large (6.35-7.06 cm). The average height of fruits of the studied hybrids varied between 48.22 mm at Cronos F₁ and 52.8 mm at Monroe F₁. The index of fruit shape was calculated as a ratio between the height and the diameter of fruit. Most of hybrids registered for the index of fruit shape very close values (0.88) by the mean of the experiment (0.86) being qualified as slightly flattened. The most flattened fruits were observed for Monroe F₁ and Menhir F₁.

The firmness of fruits was appreciated on a scale from 1 to 10 as good for all hybrids. The lowest firmness was recorded for Marissa F₁ but all the other hybrids recorded values over 9 which mean firm flesh and thick pericarp, important characteristics for the fresh tomato recommended for consumption.

Tab. 2

Early and total yield of six tomato hybrids cultivated in greenhouses

Hybrid	Early yield				Total yield			
	Kg/m ²	%	±D	Signification	Kg/m ²	%	±D	Signification
Monroe F ₁	3.38	83.3	-0.68	000	11.60	106.9	0.75	***
Marissa F ₁	4.19	103.4	0.14	-	11.08	102.1	0.23	*
Tolstoi F ₁	3.16	77.9	-0.89	000	8,22	75.8	-2.63	000
Cronos F ₁	3.73	91.9	-0.33	000	10.40	95.9	-0.45	000
Menhir F ₁	5.22	128.8	1.17	***	11.74	108.2	0.89	***
Shanon F ₁	4.65	114.7	0.60	***	12.04	111.0	1.19	***
Mean of the experiment	4.05	100.0	0.00	Control	10.85	100.0	0.00	Control
LSD 5%			0.15				0.20	
LSD 1%			0.21				0.29	
LSD 0.1%			0.30				0.42	

Tab. 3

Quality of yield of six tomato hybrids cultivated in greenhouses

Hybrid	Yield kg/m ²			Ratio from the total yield:		Extra + I st quality in comparison with control
	Total	Extra	Extra+I st quality	Extra	Extra+I st quality	
Monroe F ₁	11.60	8.81	10.90	75.95	93.97	109.11
Marissa F ₁	11.08	8.02	10.36	72.38	93.50	103.70
Tolstoi F ₁	8.22	4.71	7.20	57.30	87.59	72.07
Cronos F ₁	10.40	5.68	9.08	54.62	87.31	90.89
Menhir F ₁	11.74	9.17	11.0	78.11	93.70	100.92
Shanon F ₁	12.04	9.37	11.37	77.82	94.44	113.81
Mean of the experiment			9.99			100.00

Tab. 4

Physical characteristics of fruits at six tomato hybrids cultivated in greenhouse

Hybrid	Fruit weight (g)	Fruit height (mm)	Fruit diameter (mm)	Index of fruit shape	Fruit firmness
Monroe F ₁	130.7***	53.50*	66.21***	0.81	9.1
Marissa F ₁	96.20 ⁰	50.18	57.24	0.88	8.8 ⁰
Tolstoi F ₁	91.20 ⁰⁰	49.17	55.92 ⁰	0.88	9.4
Cronos F ₁	88.20 ⁰⁰⁰	48.22 ⁰	55.32 ⁰⁰	0.88	9.1
Menhir F ₁	120.80***	52.64	62.54*	0.84	9.6
Shanon F ₁	99.40	51.34	58.38	0.88	9.6
Mean of the experiment (control)	104.42	50.84	59.27	0.86	9.27
LSD 5%	7.60	2.57	2.73	0.06	0.46
LSD 1%	10.17	3.45	3.66	0.08	0.65
LSD 0.1%	13.30	4.51	4.79	0.11	0.95

The values of the correlation coefficients of the physical characteristics which determine the commercial tomato fruit aspect (shape, firmness) and the biometrical characteristics which determine the yield potential (fruit weight, number of fruits in the inflorescences) are presented in table 5. They can be remarked very significant positive correlations between fruit weight and fruit height as well as between fruit weight and fruit diameter. The fruit height and the fruit diameter were also strongly positively correlated ($r=+0.952^{***}$). Both fruit weight and fruit diameter were strongly negatively correlated with the index of fruit shape which means that the heaviest fruits had flattened shape. Fruit firmness is negatively even if not significantly correlated with index of fruit shape and fruit diameter which means that slightly flattened fruit are the most firm. The negative correlation coefficients among the mean number of fruits in the first seven inflorescences and fruit weight, fruit height and fruit diameter indicates that the higher the number of fruits in the inflorescence the lower the number of them. The firmness is also better in case of small to medium sized fruits than in case of large sized fruits.

Tab. 5

The correlation coefficient (r) of the physical characteristics of fruits at six tomato hybrids cultivated in greenhouse

Correlated properties	Fruit height	Fruit diameter	Index of fruit shape	Fruit firmness	Mean number of fruits in the first seven inflorescences
Fruit weight	0.951***	0.995***	-0.966 ⁰⁰⁰	0.151	-0.458
Fruit height		0.952***	-0.848 ⁰	0.260	-0.505
Fruit diameter			-0.968 ⁰⁰⁰	-0.035	-0.457
Index of fruit shape				-0.035	0.352
Fruit firmness					0.433

r 5% = 0.754; r 1% = 0.875; r 0.1% = 0.951

The evaluation of tomato fruits quality supposes besides physical characteristics, which have visual impact on consumers, also internal traits which have organoleptic impact. The internal tomato fruits quality was assessed by content of chemical components as soluble solids, total sugar, titratable acidity and vitamin C (Tab. 6). Soluble solid content of fruits varied between 4.70% in Menhir F₁ and 6.18% in Marissa F₁. The same hybrids recorded the

lowest (2.53%) respectively the highest (2.95%) total sugar content. It has to be remarked the positive significant correlation ($r = +0.795^*$) between soluble solids and total sugar content of fruits of the analyzed hybrids. Despite the fact that cultivars with high soluble solids have high sugar concentrations, soluble solids do not relate to a perception of sweetness by consumers. Soluble solids relate to the perception of fruit acidity, bitterness, astringency, and saltiness (Baldwin *et al.*, 1991). Sourness assessed by titratable acidity (as % of malic acid) varied between 0.64% in Shanon F₁ and 0.99% in Monroe F₁. Many studies have shown that tomato flavor is related to the balance between sugars and organic acids (sugars:acids ratio) in the fruits (Auerswald *et al.*, 1999). The correlation between total sugar content and acidity was positively ($r = +0.450$) for the analyzed hybrids even it was not significantly. With good levels of sugar and acidity, thus with greater sweetness, sourness, tomato-like character and flavor intensity were remarked Monroe F₁, Tolstoi F₁ and Cronos F₁.

Unfortunately, the inverse relation between yield and total solids, respective soluble solids as major constituent of dry matter (Davies and Hobson, 1981) was found in the experiment through the negative correlation between fruits weight (as productivity character) and fruits soluble solid content (Tab.7).

Vitamin C is a health-promoting factor with antioxidant properties. Among the studied hybrids the highest content of vitamin C was recorded in Monroe F₁, Tolstoi F₁ and Cronos F₁, the same hybrids with the best balance between total sugar and acidity.

Tab. 6

Fruit quality characteristics of six tomato hybrids cultivated in greenhouse

Hybrid	Fruit density (g/cm ³)	Soluble solids	Total sugar %	Titratable acidity (%)	Vitamin C mg/100 g
Monroe F ₁	1.02	5.60	2.80	0.99	20.77
Marissa F ₁	0.97	6.18*	2.95	0.75	18.83
Tolstoi F ₁	1.03	5.85	2.76	0.86	23.23
Cronos F ₁	0.97	5.43	2.87	0.80	19.36
Menhir F ₁	0.99	4.70 ⁰⁰	2.53	0.72	19.01
Shanon F ₁	1.02	5.43	2.58	0.64	16.02
Mean of the experiment (control)		5.53			
DL 5%		0.58			
DL 1%		0.82			
DL 0.1%		1.19			

Tab. 7

The correlation coefficient (r) of some physical and chemical characteristics of fruits at six tomato hybrids cultivated in greenhouse

Correlated properties	Fruit density	Soluble solids	Total sugar	Titratable acidity	Vitamin C
Fruit weight	0.258	-0.447	-0.365	0.391	0.006
Fruit density		0.012	-0.432	0.288	0.303
Soluble solids			0.795*	0.273	0.273
Total sugar				0.450	0.333
Titratable acidity					0.757*

r 5% = 0.754; r 1% = 0.875; r 0.1% = 0.951

CONCLUSIONS

The hybrids utilized in the experiment were of medium to strong vigor with good growth, flowering and fructification. Concerning the height of plants there were not recorded significant differences between hybrids all of them having a vigorous growth.

Menhir F₁ and Shanon F₁ can be remarked as earliness and yields which surpassed 4.5 kg/m². The same hybrids recorded the highest total yields. Despite the early yield, Monroe F₁ had a very significant total yield increase (0.75 kg/m²) in comparison with control. It can be also remarked that most of the hybrids recorded total yields over 11 kg/m².

The index of fruits shape had very close values (0.81-0.88) for all hybrids, most of them being qualified as slightly flattened. The most flattened fruits were observed for Monroe F₁ and Menhir F₁.

Fruit firmness was negatively even if not significantly correlated with fruit shape and fruit diameter which indicates that slightly flattened fruit were the most firm.

With good levels of sugar and acidity, thus with greater sweetness, sourness, tomato-like character and flavor intensity among the studied hybrids Monroe F₁, Tolstoi F₁ and Cronos F₁ were remarked.

REFERENCES

1. Auerswald, H., P. Peters, B. Brückner, A. Krumbein and R. Kuchenbuch (1999). Sensory analysis and instrumental measurements of short-term stored tomatoes (*Lycopersicon esculentum* Mill.). Postharvest Biol. Technol. 15:323–334.
2. Baldwin, E. A., M. O. Nisperos-Carriedo and M. G. Moshonas (1991). Quantitative analysis of flavor and other volatiles and for certain constituents of two tomato cultivars during ripening. J. Am. Soc. Hort. Sci. 116:265–269.
3. Davies, J. N. and G. E. Hobson (1981). The constituents of tomato fruit—the influence of environment, nutrition, and genotype. Crit. Rev. Food Sci. Nutr. 15:205–280.
4. Gruda, N. (2005). Impact of Environmental Factors on Product Quality of Greenhouse Vegetables for Fresh Consumption. Critical Reviews in Plant Sciences. 24(3):227-247.
5. Kader, A. A. (2002). Postharvest biology and technology: an overview. In: Kader, A.A. (ed) Postharv. Technol. Hort. Crops. 3rd ed. Pub. No. 3311. Oakland: Univ. Calif.:39-47.
6. USDA (1991). U. S. Standards for Grades of Fresh Tomatoes. USDA, Agr. Mktg. Serv., Washington, DC.