Ciencia e Investigación AGRARIA

Cien. Inv. Agr. 38(2):211-217. 2011
www.rcia.uc.cl

CROP PRODUCTION

RESEARCH NOTE

Performance of tomato (*Solanum lycopersicum*) cultivars in a tropical sheltered production system

Mayte Piñón
Instituto de Investigaciones Hortícolas "Liliana Dimitrova", Carretera Bejucal-Quivicán Km 33 ½, La Habana, Cuba, CP33500.

Abstract

M. Piñón. 2011. Performance of tomato (*Solanum lycopersicum*) cultivars in a tropical sheltered production system. Cien. Inv. Agr. 38(2): 211-217. Off-season vegetables become expensive so new technological systems are required to grow cultivars well adapted to climatic conditions throughout the year. Accordingly, a trial was performed to test 12 tomato F_1 commercial hybrids in a Cuban sheltered installation based on the "umbrella" effect recommended for tropical conditions. The main goal of the trial was to study cultivar productivity and adaptation traits before offering recommendations to growers. The ´37242´ (7.4 kg plant^{-1}) and ´Setcopa´ (7.1 kg ha^{-1}) F_1 hybrids showed the highest marketable yields, commercialized at 93% and 87%, respectively. The performance of the ´37242´ was notable; its high fruit set (87%) during the hot and wet season showed its adaptation to the local conditions. The studied cultivars were asymptomatic to tomato yellow leaf curl virus (TYLCV), despite its high prevalence in the area.

Key words: Cultivar trials, tomato, transfer of technology, tropical sheltered system.

Introduction

Vegetables are currently in high demand around the world because of their flavor and nutritive qualities, but they become expensive in the off season. Therefore, some growers have changed their production system to extend the time during which they can offer fresh vegetables. The use of advanced technology to grow sheltered crops is now known worldwide. Sheltered production systems can foster agricultural yields of vegetables. For example, tomatoes can be grown throughout the year in a system of this kind. However, introducing this technology is not sufficient in itself. The design of the structure housing the system, the covers used to produce shelter, the management of the crop and the cultivars to be grown must first be adapted for use with the technology by considering the climatic conditions prevailing in each country (Depestre *et al*., 2006).

In Cuba, sheltered horticultural technology is now widely developed. The system used is based on the "umbrella" effect and serves to protect the plant from rain and the excess sunlight that prevails during the hot and rainy season in tropical areas (Langlais and Ryckewaert, 2002).

A large number of tomato cultivars (*Solanum lycopersicum* L.) developed in temperate climates are recommended for different greenhouse sys-

Received January 4, 2010. Accepted April 12, 2011.
Corresponding author: mayte@liliana.co.cu

tems, either for sowing in soil or for use with an inert substrate. New hybrids have been developed in increasing numbers for this purpose. These hybrids are able to produce more fruit than improved tomato genotypes grown in an open field (Anderson, 1996). Large-fruit hybrids generally have a higher yield than cluster fruits (Hochmuth *et al.,* 2000).

Under Cuban conditions, it is necessary to search for cultivars that may be used in the sheltered system with the "umbrella" effect and that exhibit resistance to the tomato yellow leaf curl virus (TYLCV). Variety tests are required to select improved genotypes that are better adapted to the environment because new varieties are always being developed arise each time.

The objective of this work was to study productivity indicators and adaptation in a group of tomato hybrids before their adoption by growers for agricultural production.

Materials and methods

The study was conducted at the Instituto de Investigaciones Hortícolas "Liliana Dimitrova" (IIHLD), located in the Quivicán municipality, in Havana, Cuba (22° 23` north latitude and 82° 23`west longitude) at 11 m asl. The trial was performed from March through July 2007 in an A12 Tropical crop greenhouse from the Carisombra Company (Cuba-Spain). The greenhouse was 12 m wide and 45 m long, with a total area of 540 m^2 and 4.4 m of ridge height. The volume/surface relation of the installation was 3.35 m. The installation's "umbrella" effect serves to protect the plants from rain and decreases the exposure of the plants to the high global radiation of the intertropical warm regions. This design allows higher plant ventilation. The method used to supply ventilation is to cover the installation with a superior (placed above the plants) polyethylene fencing PE or plastic raffia with a zenith window and placing a front and sidehade net 35% shading, or by simply lifting or lowering the anti-insect netting laterally and at the front. This method allows continuous air ventilation. The increased temperatures produced in the interior of enclosed greenhouses by anti-insect netting is thereby avoided (Casanova *et al.,* 2007).

The plants were sown on March 13, 2007 in an organic substrate enriched with litonite (loaded zeolite) in flexible polyethylene trays with 32.5 cm^3 alveoli and transplanted on April 10, 2007. The development and production phases of the trial were both conducted during the spring-summer season. During the study period, the average minimum temperature at the study location was 22.6 °C, the maximum temperature was 30 °C and the global radiation was 63 watt m^{-2}. The plants were sown in double rows in high beds. The distance between rows was 0.60 m and between plants was 0.35 m. The density was 1.5 plants m^{-2}. The plant was trained vertically with tangled leaves using a plastic cord and led to only one axis. The terminal bud of the plant was maintained at approximately 1.20 m from the soil by tying down the plants Such that this practice was followed to produce a suitable microclimate for the plants. The cultivation and management procedures used for the tomato beds followed the specifications for tomatoes in the Manual for Sheltered Production of Vegetables (Casanova *et al.,* 2007).

Methods for pollination improvement were not used. The fruits were harvested at the initial half-ripe stage (Suslow and Cantweel, 2001) and were classified by caliber, as determined by the maximum diameter of the equatorial section, to assign a sales category according to Cuban Quality Standard NC-131:2001. Harvests were conducted weekly for 60 days.

Bemisia tabaci control was not applied. As a result, the performance of the cultivars against the TYLCV could be observed under conditions that allowed natural infection.

The test used 12 F_1 tomato hybrids (Table 1). These hybrids were chosen to represent the wide variety of hybrid seeds available in the present Cuban market.

The following traits of the hybrids were evaluated at harvest: number of flowers and fruits and fruit set in the first fourth clusters (Florido,

Table 1. Origin of the tomato cultivars tested.

Cultivar	Origin	Description
37208	Clause, France	Semi-determinate, round shape, TYLCV resistant
37241	Clause, France	Indeterminate, round shape, TYLCV resistant
37242	Clause, France	Indeterminate, round shape, TYLCV resistant
37243	Clause, France	Indeterminate, pear shape, TYLCV resistant
37253	Clause, France	Indeterminate, round shape, TYLCV resistant
37284	Clause, France	Indeterminate, pear shape, TYLCV resistant
38102	Clause, France	Indeterminate, round shape, TYLCV resistant
38104	Clause, France	Semi-determinate, pear shape, TYLCV resistant
3206	Hazera, Israel	Indeterminate, round shape, TYLCV resistant
3209	Hazera, Israel	Indeterminate, round shape, TYLCV resistant
Setcopa	Ense Zaden, Netherlands	Indeterminate, round shape, TYLCV resistant
Agean	Ense Zaden, Netherlands	Indeterminate, round shape, TYLCV resistant

2007); number of clusters per plant; number, mean weight and yield of extra-grade fruits (fruits having an equatorial diameter greater than 7.5 cm, percentage of the total); number, mean weight and yield of superior-grade fruits (fruits having an equatorial diameter between 6.5 and 7.4 cm, percentage of the total); number, mean weight and yield of second-grade fruits (fruits having an equatorial diameter less than 6.5 cm, percentage of the total); commercial yield (total percentage of fruits in the extra- and superior-grade categories); yield per plant; pericarp thickness; percentage of soluble solids; and peduncle depth in the fruit.

A randomized block design was used. Treatments were represented by hybrids. Each treatment consisted of three furrows, each 2.5 meters in length. This arrangement was repeated three times in the installation. The number of plants per treatment was 15 and 9 per useful plot of hybrids. Statistically significant overall variation among treatment means was further analyzed by comparing the individual means using the Tukey test ($P \leq 0.05$). The computer program Statgraphics Plus 5.0 was used. A Principal Component analysis was performed (PC) to identify the major components representing the contributions of the individual traits to the observed variability.

Results and discussion

The yield of the cultivars during the test varied between 2.85 kg and 7.40 kg per plant. The variation in yield among the cultivars was statistically significant. The hybrids ´37242´ and ´Setcopa´ were the most productive (7.40 kg and 7.10 kg plant^{-1}, respectively). These values were not significantly different. Cultivar ´3209´ had the lowest yield (2.85 kg plant^{-1}). This value differed significantly from the values found for the other cultivars.

The commercial yield found in the trial varied between 75% and 96%. The yield of the upper category (extra) varied between 0% and 73%. It is noteworthy that although cultivars ´37242´ and ´Setcopa´ had commercial yields of 93% and 87%, respectively, cultivar ´37242´ yielded 55% extra-grade fruits and 38% superior-grade fruits, whereas ´Setcopa´

Table 2. Productivity characteristics of the tomato cultivars tested.

Cultivar	Extra grade yield (%)	Superior grade yield (%)	Commercial yield (%)	Mean fruit weight (g)	Yield/ plant (kg)	Pericarp thickness (mm)	Soluble solids (%)	Peduncle depth (cm)
37208	72	22	94	216	3.40 d	5.7	3.1	3.0
37241	60	32	92	164	4.25 d	5.2	2.7	1.4
37242	55	38	93	166	7.40 a	1.8	3.2	3.3
37243	0	91	91	127	3.55 e	1.8	3.2	3.3
37253	38	50	88	149	5.30 c	7.3	3.9	2.0
37284	0	81	81	107	6.60 b	5.3	3.0	3.1
38102	35	40	75	153	3.95 e	7.0	2.5	3.3
38104	0	96	96	149	3.25 e	6.3	3.0	2.4
3206	17	65	82	139	3.70 e	5.8	3.0	2.1
3209	38	46	84	169	2.85 f	4.7	3.3	2.3
Setcopa	16	71	87	158	7.10 a	7.3	3.0	1.7
Agean	73	23	96	197	4.15 d	5.5	3.0	2.5

Mean values followed by different letters within each column are significantly different at $P \leq 0.05$.

yielded only 16% extra-grade and 71% superior-grade. ´Setcopa´ was therefore the least profitable in the Cuban market, where the fruit caliber determines the sales categories. Hybrid ´38102´ showed the lowest commercial yield (75%) (Table 2).

Table 3 shows that the hybrid ´37242´ exhibited the best adaptation. This hybrid reached a fruiting value of 87%. The hybrid ´37241´ had a fruit set of 81% but also exhibited a longer productive cycle and was therefore discarded. In tropical regions, the conditions for tomato production are risky owing to climate variability; therefore, the use of early cultivars is recommended (Gómez *et al.,* 2000).

The hybrids that produced the highest yields of extra-category fruits, ´Agean´ (73%) and ´37208´ (72%), had the highest average fruit weight (197 and 216 g, respectively).

The quality of fruit is a complex criterion. External and internal appearance, flavor, aroma and texture are all aspects of fruit quality. The quality of fruit is strongly influenced by the environment and is independent of the amount of fruit produced (Causse, 2007). Therefore, the evaluation of aspects related to quality becomes relevant in tests of cultivars. Hybrids ´37253´ and ´Setcopa´ showed the highest pericarp thickness (7.3 mm) of all the hybrids tested. This property contributes to the firmness of the fruit and thus helps prevent damage. In cultivars ´37241´ and ´Setcopa´, the peduncle penetrates only 1.4 and 1.7 cm in the fruit, respectively; consequently, these cultivars exhibit a better internal aspect. None of the hybrids tested were distinguished by their content of soluble solids.

A significant degree of splitting was not evident in the trial. Splitting did not affect the commercial yield. This finding may be explained by crop management. Likewise, no evidence of blossom end rot was observed. The plants tested did not show TYLCV symptoms under conditions of natural infection.

Table 3. Measurement of the climatic adaptation of the cultivars tested.

Cultivar	Fruit set (%)	Number of flowers in first 4th clusters	Number of fruits in first 4th clusters	Number of clusters/ plant
37208	80 ab	44.5 b	35.5 cd	14 c
37241	81 ab	69.0 b	55.0 b	15 bc
37242	87 a	65.0 b	55.5 b	16 bc
37243	72 abc	124.0 a	89.0 a	20 ab
37253	81 ab	69.0 b	53.5 b	13 c
37284	73 abc	103.5 a	73.0 a	17 bc
38102	64 bc	68.0 b	43.5 bc	23 a
38104	56 c	50.0 b	26.0 d	12 c
3206	69 abc	54.4 b	37.6 cd	15 bc
3209	72 abc	24.8 c	18.0 f	8 d
Setcopa	57 c	69.2 b	39.2 cd	13 c
Agean	46 d	48.8 b	22.4 e	12 c

Mean values followed by different letters within each column are significantly different at P≤0.05.

The PC helped to identify the factors influencing the yield of F_1 hybrids used in the sheltered system under tropical conditions. The first two components extracted 72% of the variability present in the cultivars tested (Table 4). The first component (C1) and the second component (C2) may be considered to represent productivity. The greatest contribution to the first component was made by the number of superior-grade fruits. The second component reflected the contributions of yield, fruit set and the number of extra-category fruits. The signs of all of these contributions were positive. This result shows that, regardless of the variations found in the yields, the percentages of extra-category fruits and fruit set, positive correlations occurred between the traits of extra-category fruit percentage and fruit set and between each of these traits and yield (Table 5).

In Cuba, the expected yield in tomato is 130 to 180 t year^{-1}. Winter production varies between 80 and 110 t ha^{-1}, whereas spring-summer production varies between 50 and 70 t ha^{-1}. The exact values obtained will depend on the cultivar used, the date of harvest and the management practice applied (Casanova *et al.*, 2007). These yield values are included in the Guidelines and Methodology to Evaluate the System of Sheltered Crops in Cuba (Grupo Técnico Asesor de Cultivos Protegidos, 2010). This study shows that some cultivars, like ´37242´, may offer potentially-higher yields (111 t ha^{-1}, 7.40 kg plant^{-1}) in the spring-summer season if grown

Table 4. Accumulated variability determined by Principal Component analysis.

Principal Components (PC)	Eigenvalue	Variability (%)	Accumulated variability (%)
1	5.63	46.97	46.97
2	3.00	25.03	72.00
3	1.40	11.68	83.68
4	1.29	10.82	94.50

Table 5. Correlation between the studied variables and the components.

Principal Components (PC)	C1	C2	C3	C4
Fruit set	0.1363	0.4868	-0.1967	-0.0218
Fruits/plant superior grade	-0.4046	0.1096	0.0045	-0.1163
Fruits/plant second grade	-0.2965	0.1889	0.4659	0.1604
Fruits/plant extra grade	0.2561	0.4244	-0.1061	0.0007
Pericarp thickness	0.0874	-0.1808	0.6623	-0.4310
Clusters/plant	-0.0684	-0.0372	0.2665	0.8065
Fruits/plant	-0.3137	0.3708	0.1201	-0.0372
Mean fruit weight superior grade	0.3714	-0.0444	0.0650	0.3084
Mean fruit weight second grade	0.3245	0.1968	0.3600	-0.1315
Mean fruit weight extra grade	0.3645	0.2299	0.2549	0.0768
Mean fruit grade	0.3928	0.0122	-0.0963	-0.0530
Yield/plant	-0.1553	0.5194	0.0231	-0.0361

using the sheltered system with the "umbrella" effect. Gómez *et al*. (2000) state that the sheltered system represents a unique possibility for tomato production in Cuba during the hottest and rainy season or tropical spring-summer season. Tests like this, in which the traits from the new varietal achievements appearing on the seed market are studied, may help local growers select the most useful cultivars (Gent, 2003).

Resumen

M. Piñón. 2011. Comportamiento de doce cultivares de tomate (*Solanum lycopersicum*) en el sistema de producción protegido tropical. Cien. Inv. Agr. 38(2): 211- 217. Los productos hortícolas adquieren elevados precios fuera de estación, por lo que es ventajoso desarrollar el sistema productivo protegido que posibilite extender su oferta durante todo el año; éstos requieren previamente ser adaptados, incluyendo los cultivares, teniendo en cuenta las condiciones climáticas de cada país. En consecuencia, se llevó a cabo un ensayo con doce híbridos F_1 comerciales de tomate, provenientes de países templados, con diseño de bloques al azar, en una instalación protegida basada en el efecto "sombrilla", recomendada en clima tropical**.** El objetivo fue estudiar indicadores de productividad y adaptación en los mismos, previo a su adopción práctica. Los híbridos ´37242´ (7,4 kg planta^{-1}) y ´Setcopa´ (7,1 kg planta^{-1}) se mostraron como los más productivos, con rendimientos comerciales de 93 y 87%, respectivamente. En el comportamiento de ´37242´ debió influir la alta fructificación lograda (87%) durante el período caliente y húmedo, lo que demuestra su adaptación. Los híbridos estudiados no mostraron síntomas del Virus del enrollamiento amarillo de la hoja del tomate (TYLCV), a pesar de su alta incidencia ambiental.

Palabras clave: Ensayos de cultivares, sistema de producción protegida tropical, tomate, transferencia de tecnología.

References

Anderson, R. 1996. Greenhouse tomato production practices. University of Kentucky, Dept. of Horticulture Pub. Available online at: http://www.uky.edu/Agriculture/Horticulture/anderson/ghtom.htm (Website accessed: November 2, 2009).

Casanova, A. S, O. Gómez, F. Pupo, and M. Hernández. 2007. Manual para la producción protegida de hortalizas. Editorial Liliana, La Habana. 138 pp.

Causse, M. 2007. Genétique et amelioration des fruits et legumes. Available online at: http://www.avignon.inra.fr/gafl/fr/personnes/mathilde_causse (Website accessed: noviembre 20 de 2009).

Depestre, T., M. Piñón, and O. Gómez. 2006. Sistema protegido de producción hortícola. Proyecto Nº XIX. 2. Estructuras de protección para zonas intertropicales. Programa Ciencia y Tecnología para el Desarrollo (CYTED). La Habana, Cuba.

Florido, M. 2007. Evaluación de la tolerancia al calor en muestra de germoplasma de tomate (*Solanum* L. sección *Lycopersicon* subsección *Lycopersicon*) conservado *ex situ* en Cuba. Tesis en opción al grado científico de Doctor en Ciencias Agrícolas. Instituto Nacional de Ciencias Agrícolas (INCA). La Habana, Cuba. 101 pp.

Gent, M.P.N. 2003. Greenhouse tomato cultivar trials in Connecticut 1999 - 2002. Connecticut Agricultural Experiment Station, New Haven. Bulletin 990. 16 pp.

Gómez, O., A.S. Casanova, H. Laterrot, and G. Anaïs. 2000. Mejora genética y manejo del cultivo del tomate para la producción en El Caribe. Ediciones Liliana, La Habana. 159 pp.

Grupo Técnico Asesor de Cultivos Protegidos. 2010. Lineamientos para el desarrollo del Sistema Productivos de Cultivos Protegidos. Ediciones Liliana. La Habana, Cuba. 28 pp.

Hochmuth, R.C., L.L. Davis, and N. Tillman. 2000. Evaluation of greenhouse beefsteak and cluster tomato varieties for north Florida, 1999-2000 season. University of Florida, North Florida Research and Education Center Suwannee Valley, Res. Report 2000-02. 5 pp.

Langlais, C., and P. Ryckewaert. 2002. Guía de los cultivos protegidos de hortalizas en zona tropical húmeda. CIRAD-FLHOR. Montpellier, France. 91pp.

Suslow, T., and M. Cantweel. 2001. Tomate (jitomate), recomendaciones para mantener la calidad postcosecha. Department of Vegetable Crop. University of California, Davis. Available online at: http:www.mag.go.cr/biblioteca_virtual_ciencia/tec-poscosecha-tomate-cap-VI-VIII (Website accessed: November 5, 2009).