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Original article

Morfoagronomical evaluation of tomato Cuban cultivars (*Solanum lycopersicum* L.) in Granma province

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ABSTRACT

Morphoagronomical characteristics were evaluated in six tomato cultivars at two localities at Granma province. In both places was used the method of transplanting at plots of land of 28 m^2, distributed in a random blocks design with four replies. 13 variables were evaluated, to whose data applied a principal component analysis, Bi-factorial analysis of variance was used and the multiple comparisons of means were made by Tukey test for $p \leq 0.05$. The 62 % of the evaluated variables evidenced a high contribution to the total variation. A significant effect of the interaction ambient genotype detected and yield average of the cultivars in the Experimental Agricultural Station of the Institute of Agricultural Investigations Jorge Dimitrov was 48.3 t ha^{-1}, which represent 88 % increment in relation to the UBPC Tamara Bunke, at Río Cauto municipality.

Key words: environments, contribution, variance, genotype, interaction

INTRODUCTION

The tomato fruit (*Solanum lycopersicum* L.) is valued worldwide because it is an essential component for the diet of millions of people [(1)]. Its demand continually increases and with it its cultivation, production and trade [(2)]. Fresh consumption and industry are the two main production destinations [(3)].

The tomato has good nutritional quality and constitutes a vitamin contribution for the population. It is also attributed medicinal properties such as digestive, disinfectants, antiscorbutics, etc. It also contains potassium, fiber, and beta-carotene, precursor of vitamin A, and is a valuable source of lycopene, which plays an important role as a functional food in the prevention of disease (4).

In Cuba, the yields achieved are low, as in the vast majority of tropical countries, due to the negative effect of climatic factors and the high incidence of pests (5).

Tomato cultivation in Cuba, in a field production system, requires cultivars adapted to the conditions of the tropical climate. The availability by producers of Cuban cultivars with these characteristics constitutes an advantage over the varieties introduced to extend the dates of planting and harvesting (6).

The tomato has a high genetic diversity, in which there are innumerable varieties with different aspects, colors and flavors (3), which show different responses when grown in contrasting environments.

Morphoagronomic characterization allows the identification of desirable traits in individuals intended to be introduced directly as cultivars or used as gene donors (7).

The objective of the present work was to evaluate morphoagronomic characteristics in six Cuban tomato cultivars in two locations in the Granma province.

MATERIALS AND METHODS

In the period November/2016 and April/2017, the tomato cultivars Vyta, INCA 9(1), L-10-3, Criollo Quivicán, L-316 and Buena Ventura were evaluated in Vertisol Pélico soil (7). It was from the Basic Unit of Cooperative Production (UBPC) Tamara Bunke: locality 1 (L1), belonging to the Río Cauto municipality; and in a mollic Fluvisol soil (8) at the Agricultural Experimental Station of the Agricultural Research Institute "Jorge Dimitrov": locality 2 (L2), in Bayamo municipality, both in Granma province.

The chemical composition of the soils and the climatic indicators evaluated are shown in Tables 1 and 2, respectively. The chemical characteristics of the soil were determined at the Provincial Soil and Fertilizer Laboratory in the Granma province, using conventional techniques and climatic data were obtained at the Jucarito Meteorological Station, in Río Cauto municipality, and at the Provincial Delegation of CITMA in Granma.

Table 1. Chemical composition of the soils in the experimental areas

Locality	**pH**		**MO**	**P_20_5**	**K_20**	**Ca**	**Mg**	**K**	**Na**
	kcl	**H_2O**	**%**	**Mg/100g.**		**Meq/100g**			
L1	6.3	4.98	2.25	3.82	16.87	26.77	3.50	0.39	0.31
L2	6.43	7.0	3.27	6.26	31.5	13.33	5.20	0.22	0.15

L1: UBPC Tamara Bunke, L2: Agricultural Experiment Station of the Institute of Agricultural Research ″Jorge Dimitrov″

Table 2. Climatic data of the localities during the experimental development

Months	L1			L2		
	P (mm)	Tm (ºC)	RH (%)	P (mm)	Tm (ºC)	RH (%)
November	25.4	24.9	82	34.2	25.3	79
December	4.0	24.6	85	84.2	25.2	78
January	12.6	24.5	79	6.3	24.6	78.3
February	10.0	25.4	78	87.3	23.5	75.1
March	10.0	26.3	79	47.2	25.7	71.5

L1: UBPC Tamara Bunke, L2: Agricultural Experimental Station of the Institute of Agricultural Research "Jorge Dimitrov", P: rainfall, Tm: average temperature, RH: relative humidity

Organic fertilization with sheep manure, applied manually at the bottom of the furrow at the time of transplantation, at a rate of 5 t ha^{-1}. Weed control was performed with a hoe manually, keeping the experiment free of undesirable plants during its execution. Furrow irrigation at the time of transplanting, flowering and fruiting. The rest of the cultural services were carried out according to the technical instructions for tomato cultivation [9].

The following variables were evaluated

Number of primary branches per plant: The number of primary branches on ten plants was randomly counted after harvest in each plot.

Leaf length (cm): Measured with a graduated ruler on a leaf of ten random plants after flowering in each plot.

Leaf width (cm): Measured with a graduated ruler on a leaf of ten random plants after flowering in each plot.

Number of bunches per plant: It was counted in ten random plants in each plot.

Plant height (cm): It was measured with a tape measure, from the soil surface to the apex of the main stem, in ten plants taken at random after harvest in each plot.

Stem diameter (cm): It was measured with vernier caliper, 10 cm from the soil surface, in ten random plants after harvest in each plot.

Number of fruits per bunch: Counted in ten bunches of ten plants at random in each plot.

Number of fruits per plant: It was counted in ten random plants in each plot

Fruit mass per plant (kg): With a 10 kg weight, all fruits of 10 plants taken at random in each plot were weighed individually.

Average fruit mass (g): Result of dividing the fruit mass per plant by the number of fruits per plant.

Equatorial diameter of the fruit (cm): It was measured with vernier caliper, by the average part of 10 random fruits in each plot.

Fruit polar diameter (cm): It was measured with vernier caliper in 10 random fruits in each plot.

Yield (t ha^{-1}): It was calculated on the basis of the fruit mass in the calculation area of each plot.

The data was processed with the use of the Statistical package [(10)]. A principal component analysis was performed to determine the variables with the greatest contribution to the total phenotypic variance. A two-factor analysis of variance was performed to the variables with the greatest contribution, using varieties and localities as factors. Multiple comparison of means was performed using the Tukey test for $p \leq 0.05$.

RESULTS AND DISCUSSION

The main components analysis (Table 3) showed that the first two components explained 81.10 % of the total variation. Component C1 extracted 48.93 % and it was characterized by the variables number of clusters per plant, stem diameter, fruit mass per plant, equatorial diameter of the fruit, polar diameter of the fruit and the yield, which showed a relationship directly proportional.

Table 3. Results of the Principal Component Analysis in 13 agronomic variables in Cuban tomato varieties evaluated in two locations in the Granma province

Main axes	**C1**	**C2**
Own values	5.58	2.62
Contribution to total variation (%)	48.93	32.17
% accumulated	48.93	81.10
Eigenvectors		
Eigenvectors Number of primary branches per plant	-0.484229	-0.348530
Blade length	-0.379277	-0.482717
Blade width	-0.116225	0.341099
Number of bunches per plant	**-0.875215**	-0.141375
Plant height	-0.087355	-0.691747
Stem diameter	**-0.842309**	-0.069540
Number of fruits per bunch	-0.051394	**-0.769757**
Number of fruits per plant	-0.664282	-0.515274
Fruit mass per plant	**-0.901987**	0.128170
Average fruit mass	-0.301402	**0.781874**
Equatorial diameter of the fruit	**-0.901722**	0.268988
Fruit polar diameter	**-0.821025**	0.268764
performance	**-0.932985**	0.131095

Own vectors Number of primary branches per plant Component C2 explained 32.17 % and was characterized by the variables number of fruits per bunch and average fruit mass with an inverse relationship between them.

61.50 % of the variables showed a significant contribution to the total phenotypic variance and 38.50 % expressed a low contribution, therefore they were excluded from this study, since the main components indicate in what way and with what importance the variables participate in the formation of linear combinations, which allows discarding variables in a given problem (11).

The analysis of variance applied to the variables with the greatest contribution to the total phenotypic variance (Table 4) exhibited significant differences ($p \leq 0.05$) in the variety x locality interaction in all the variables evaluated, except for the fruit mass per plant and the yield, which only showed differences between varieties and localities.

Table 4. Behavior of the variables with the greatest contribution to the total phenotypic variance in Cuban tomato cultivars evaluated in two localities in the province of Granma

Source of variation	NRP	DT (cm)	PFP (kg)	DEF (cm)	DPF (cm)	NFPR	MPF (g)	YIELD (t ha^{-1})
Variety (V)	5.08	0.021*	0.1743*	88.96*	0.0471	0.6876*	177.10*	121.74*
Locality (L)	224*	0.585*	3.822*	17665.95*	4.9729*	0.0025	477.93*	45.8329*
V X L	9.29*	0.019*	0.0539	102.07*	0.1625*	0.6472*	514.90*	58.08
Error	2.403	0.006	0.0321	5.13	0.0598	0.0674	26.70	26.62

NRP: number of clusters per plant, DT: diameter of the stem, PFP: fruit mass per plant, DEF: equatorial diameter of the fruit, DPF: polar diameter of the fruit, NFPR: number of fruits per cluster, MPF: average mass of the fruit, YIELD: yield

The variables that showed significance in the variety x locality interaction indicate that there were varieties that expressed different responses in the evaluated environments, which is known as environment genotype interaction. This interaction refers to the differential behavior of genotypes through variable environmental conditions (12), which is very important in the genetic improvement of crops, since it is present during the selection and recommendation process (13). The evaluation of the genetic materials in different environments and the measurement of the genotype-environment interaction gives an idea about the phenotypic stability of the genotypes in the face of environmental fluctuations (14).

Table 5 shows the responses of the cultivars in the morphoagronomic variables with the highest contribution to the total phenotypic variation. In the number of bunches per plant, the INCA 9(1), Criollo Quivicán and L-316 cultivars expressed the highest values in L2, which indicates that the edaphoclimatic characteristics of this locality positively influenced the expression of this variable in the cultivars described. The rest of the cultivars showed similar behavior in both locations, this reflects that these cultivars tolerate more environmental variations.

Table 5. Responses of the morphoagronomic variables with the greatest contribution to the total phenotypic variance in six Cuban tomato cultivars

Variedad	NRP		DT (cm)		DEF (cm)	
	L1	L2	L1	L2	L1	L2
Vyta	13.13 abcd	16.00 a	0.90 cd	1.09 abc	4.53 d	5.31 abc
INCA 9(1)	10.27 de	16.20 a	0.83 d	1.09 abc	4.75 bcd	4.41 de
L-10-3	11.33bcde	13.30 abcd	0.82 d	0.94 bcd	4.49 de	5.36 ab
Criollo Quivicán	9.83 de	15.60 ab	0.75 d	0.95 abcd	4.77 bcd	3.75 e
L-316	7.47 e	16.40 a	0.75 d	1.19 a	5.34 abc	4.58 cd
Buena Ventura	10.97 cde	15.40 abc	0.81 d	1.14 ab	4.11 de	5.96 a
EE	0.129		0.007		0.001	
Variedad	**DPF (cm)**		**NFPR**		**MPF (g)**	
	L1	**L2**	**L1**	**L2**	**L1**	**L2**
Vyta	3.20 e	3.92 abcd	2.73 bc	2.40 cd	35.43 cd	54.67 ab
INCA 9(1)	3.38 cde	4.07 abc	2.87 abc	3.4 ab	36.57 cd	28.73 d
L-10-3	3.47 bcde	4.17 ab	2.53 c	2.50 cd	28.88 d	50.40 abc
Criollo Quivicán	3.21 de	4.24 a	2.73 bc	2.60 c	41.10 bcd	40.03 bcd
L-316	3.57 abcde	3.76 abcde	2.53 c	3.5 a	53.32 ab	36.13 cd
Buena Ventura	3.09 e	4.23 a	2.67 bc	1.77 d	33.48 d	62.53 a
EE	0.02		0.021		0.431	

NRP: number of clusters per plant, DT: diameter of the stem, DEF: equatorial diameter of the fruit, DPF: polar diameter of the fruit, NFPR: number of fruits per cluster, MPF: average fruit mass, L1: Río Cauto, L2: Bayamo, EE: standard error. Means with equal letters in the same variable do not show significant differences

The stem diameter of the INCA 9(1), L-316 and Buena Ventura cultivars reached the highest values in L2. The other cultivars expressed the same behavior in both locations. When analyzing the behavior of cultivars in each locality separately, only superiority of cultivar L-316 with respect to L-10-3 is observed. The averages reached in both locations are below those reported by other authors, who pointed out that the stem diameter in these species ranges between 1.5 and 3 cm (4).

In the equatorial diameter of the fruit, the cultivars Vyta, L-10-3 and Buena Ventura stood out in L2, while the cultivar L-316 reached higher value in L1. This reflects that the expression of this variable in the last cultivar has different agro-ecological demands than the previous cultivars.

In the polar diameter of the fruit, the cultivars Vyta, Criollo Quivicán and Buena Ventura showed the highest averages in L2. The rest of the cultivars showed similar values in both locations.

Regarding the number of fruits per cluster, the cultivar L-316 stood out in L2, while the cultivar Buena Ventura did so in L1. The other cultivars did not show differences in both locations.

In the average fruit mass, the cultivars Vyta, L-10-3 and Buena Ventura achieved the highest values in L2, while the cultivar L-316 was superior in L1. The INCA 9(1) and Criollo Quivicán cultivars showed similar behavior.

Regarding the average fruit mass per plant and the yield (Table 6), the cultivar Vyta did not show significant differences with the cultivars INCA 9(1) and Criollo Quivicán, but it surpassed the rest of the cultivars, which in turn did not they differed from each other.

The Vyta cultivar has shown good adaptability in the edaphoclimatic conditions of the Granmense territory, since as it is observed the achieved yield exceeds 11.7 t ha^{-1} published as the average of the province (15), it also behaved among those with the highest yield in a study carried out in four localities in Granma province (13).

The average mass of the fruits per plant, expressed by the cultivars in the two localities, are in the range between 5 and 500 g indicated by other authors (16).

Table 6. Behavior of the average fruit mass per plant and the yield in six Cuban tomato cultivars evaluated in two locations in the Granma province

Cultivars	Average fruit mass per plant (kg)	Rendimiento (t ha^{-1})
Vyta	1.61 a	44.41 a
INCA-9-1	1.35 ab	36.05 ab
L-10-3	1.24 b	34.16 b
Criollo Quivicán	1.54 ab	40.55 ab
L-316	1.22 b	33.65 b
Buena Ventura	1.22 b	33.30 b
EE	0.014	0.429

EE: error estándar, medias con letras iguales en la misma columna no muestran diferencias significativas entre ellas

When evaluating the average behavior of these variables in the two locations under study, it was seen that the highest values were expressed in L2 (Table 7). This may be because, independently of some of the cultivars having shown a better response in some variables in L1, in general, the edaphoclimatic conditions in L2 were more favorable, since a higher content of organic matter in the soil is observed. Phosphorus, Potassium, and lower content of Sodium (Table 1). In addition, an increase in rainfall and lower values of temperature and relative humidity are observed (Table 2). Hence the importance of evaluating varieties at the local level, to select those that can express a greater productive potential according to their responses in certain environments.

Table 7. Behavior of the average fruit mass per plant and the yield of cultivars evaluated in two locations in the Granma province

Localities	Average fruit mass per plant (kg)	Yield (t ha^{-1})
L1	1.04 b	25.74 b
L2	1.69 a	48.31 a
EE	0.014	0.429

EE: standard error, means with equal letters in the same column do not show significant differences between them, according to Tukey's test p≤ 0.05

CONCLUSIONS

- The variables that most contributed to the total phenotypic variance were: number of clusters per plant, stem diameter, fruit mass per plant, equatorial diameter of the fruit, polar diameter of the fruit, yield, number of fruits per bunch and mass fruit average.
- There were cultivars that showed different responses in both locations, which shows a significant effect of the genotype-environment interaction.
- The average yield of cultivars in the Agricultural Experimental Station of the Institute of Agricultural Research Jorge Dimitrov″ was 48.3 t ha^{-1}, which represents an increase of 88 % compared to the UBPC Tamara Bunke, in the Río Cauto municipality.

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