Volumen 30, Nº 3. Páginas 29-35
IDESIA (Chile) Septiembre-Diciembre, 2012

Fruit production and classification of four cherry tomato genotypes under an organic cropping system

Producción y clasificación de frutas de cuatro genotipos de tomate cereza en sistema orgánico

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ABSTRACT

A field experiment was carried out in the Instituto de Ciências Agrárias of Universidade Federal de Minas Gerais, Montes Claros, MG, Brazil, during the summer of 2008-2009, to evaluate the productive features of cherry tomato genotypes cultivated under different spacing, in an organic cropping system. The experimental design was randomized blocks in a 3x4 factorial scheme with three replications. The experimental plot was made up of four rows (spaced 1.00 m between rows) with thirty two plants each, utilizing the eight central plants for the analysis. The treatments consisted of three genotypes of cherry tomatoes (CH152, CLN1561-A and Carolina) and four spacings between plants (0.40; 0.60; 0.80; 1.00 m). The fruit percentage in the different diameter classes and the commercial fruits yield per plant and hectare were evaluated. The CH152 genotype produced a greater percentage of non-commercial fruit (with diameter less than 20 mm). The greatest percentage of fruit classified with the largest diameters (above 30 mm) was achieved by the CLN1561A genotype. The highest commercial yields of fruit per plant and per area were found in the CLN1561A genotype, pointing it out as a promising genotype for an organic crop in the summer in the north of Minas Gerais.

Key words: *Solanum lycopersicum* L., alternative farming, plant density, productivity.

RESUMEN

Un experimento fue conducido en campo, en el Instituto de Ciencias Agrarias de la UFMG, Montes Claros, MG, Brasil, durante el verano de 2008 y 2009, para evaluar las características productivas de genotipos de tomate cereza cultivado bajo diferentes espaciamientos, en sistema orgánico. El delineamiento experimental fue el de bloques casualizados, en esquema factorial 3 x 4, con tres repeticiones. La parcela experimental fue compuesta por cuatro líneas (espaciadas por 1,00 m entre líneas) con 32 plantas cada una, adoptando como área útil las ocho plantas centrales. Los tratamientos consistieron de tres genotipos de tomate cereza (CH152, CLN1561A y Carolina) y cuatro espaciamientos entre las plantas (0,40; 0,60; 0,80; 1,00). Se evaluó el porcentaje de frutas en las diferentes clases de diámetro y los rendimientos de frutas comerciales por planta por hectárea. El genotipo CH152 produjo mayor proporción de frutas no comerciales (diámetro menor que 20 mm). La mayor proporción de frutas clasificadas con diámetros mayores que 30 mm fue alcanzada por el genotipo CLN1561A. Los mejores resultados de productividad comercial de frutas por planta y por área fueron observados en el genotipo CLN1561A.

Palabras clave: Solanum lycopersicum *L., agricultura alternativa, densidad de siembra, productividad.*

Introduction

The tomato is a vegetable consumed mainly *in natura* that is currently causing consumer concern, especially because of the possibility of contamination with chemical pesticide residues. This concern has generated a significant increase on the demand for products free of pesticides and certified by agencies such as IBD (Biodynamic Institute) (Luz *et al.*, 2007).

The tomato crop is highly susceptible to pests and diseases, and is currently the second vegetable

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Fecha de Recepción: 22 Junio, 2012.
Fecha de Aceptación: 7 Septiembre, 2012.

in which the greatest amount of chemical pesticides is used, only surpassed by potatoes (Batista *et al*., 2006); these authors also mention that the indiscriminate use of pesticides cause harm to human health and also generates environmental liability.

The advances generated by modern agriculture have led to an intense process of agricultural industrialization; the industrialization has led to profit reductions, environmental disasters, rural exodus and contaminated food on the tables of consumers. The use of agro-ecological practices aims to reduce production costs and protect the environment; this kind of proposal is the most suitable for smaller producers, since they can significantly improve their living conditions (Roel, 2002).

Changes in planting spacing and density for crops mainly aim to improve productivity; however, these changes cause many alterations in the productive physiology of plants, thus these effects should be studied (Freitas *et al*., 2009). The genotype and the appropriate spacing appropriate for the climatic and soil conditions of each region may determine a good productivity in tomato crops. The spacing directly influences the phytosanitary control and tomato yield, related to the size and weight of fruits (Penteado, 2004).

The cherry tomato (*Solanum lycopersicum* L. var. Cerasiforme) has small bilocular fruits with intense bright red color and a sweet flavor compared to other kinds of tomatoes (Filgueira, 2006). The cherry tomato type has good productivity, some resistance to pests and high commercial value (Souza & Resende, 2003). The tomato fruits are classified as giant ($\varnothing > 100$ mm), large ($100 \text{ mm} \leq \varnothing \geq 80$ mm), medium ($85 \text{ mm} \leq \varnothing \geq 65$ mm) and small ($65 \text{ mm} \leq \varnothing \geq 50$ mm); this classification is important for standardization of fruit and quality valuation for marketing (Luengo *et al*., 1999). The fruits considered as cherry type were not included in this classification; however the need to classify them into new calibers currently following the classification proposed by Fernandes *et al*. (2007) was perceived.

In the literature there is little information about cultivation and suitable management for organic cultivation of tomatoes in the northern region of Minas Gerais, Brazil. The aim of the present research was to evaluate the production of three cherry tomato genotypes as well as the classification of their fruit in relation to different planting densities, grown in an organic system.

Materials and Methods

The experiment was conducted in the period of December 2008 to April 2009 at the Instituto de Ciências Agrarias of the Universidade Federal da Minas Gerais, in Montes Claros, Minas Gerais State, in a Cambisol Haplico type of soil in which a physical-chemical analysis of soil was performed; pH of the water 5.7; available P (mg dm^{-3}) 6.0, available K (mg dm^{-3}) 280.8; Ca ($cmol_c$ dm^{-3}) 5.9; Mg (cmolc dm-3) 2.1; Al ($cmol_c$ dm^{-3}) 0.0, H + Al ($cmol_c$ dm^{-3}) 2.5, SB ($cmol_c$ dm^{-3}) 8.7; t ($cmol_c$ dm^{-3}) 8.7, m (%) 0; T ($cmol_c$ dm^{-3}) 11.2, V (%) 78.1; organic matter (dag kg^{-1}) 5.2; coarse sand (dag kg^{-1}) 8; fine sand (dag kg^{-1}) 20; silt (dag kg^{-1}) 48; clay (dag kg^{-1}) 24.

The treatments were arranged in factorial (3 x 4) scheme with three genotypes of cherry type tomatoes (Carolina, CH152 and CLN1561A) and four plant spacings (0.40; 0.60; 0.80 and 1.00 m), with 1.0 m between rows. The genotype CH152 with pear-shaped fruit and CLN1561A with oblong fruit shape were provided by AVRDC The World Vegetable Center, tolerant to race 1 of *Fusarium oxysporum f. sp. lycopersici* and mosaic virus, respectively. The experiment consisted of 36 plots with 24 plants, where the four central plants of each were analyzed. The seedlings were grown in polystyrene trays with 128 cells; a commercial substrate was used.

Transplanting was performed 25 days after sowing. The pits were fertilized with 400g of organic compost prepared with elephant grass straw (*Pennisetum purpureum*), manure and 213 g of reactive natural phosphate (9% P_2O_5 soluble in citric acid). Hand weeding and earthing up was performed at 30 and 60 days after transplanting. Drip irrigation was used; the plants were cultivated in single stem and tutored with synthetic fiber. Throughout the cultivation a commercial formulation based on neem was applied (*Azadirachta indica A. Juss.*) for the prevention of arthropods, a Bordeaux mixture for the prevention of pathogens and a bovine manure biofertilizer for plant nutrition.

The biofertilizer was prepared in an anaerobic plastic drum system with a capacity of 200L.

50 kg of fresh cattle manure, 25 kg of poultry manure, 10 kg of ash, 5 kg of sugar and water were added until it reached about 90% of the capacity of the container. After 60 days of fermentation the biofertilizer was used as foliar fertilizer, and 20L of the mixture at a concentration of 1% was applied.

Applications were made at 30-day intervals during the growing season.

The harvesting began 90 days after sowing or 65 days after transplant; this took place weekly until 150 days after sowing. Fruits were harvested at the light red maturity stage, according to the classification of Caliman *et al*. (2003). Eight harvests were performed for all genotypes; subsequently the fruits were weighed, counted and sorted by means of four plastic boxes with perforated holes in the bases of 20, 25, 30, and 35 mm diameter. The boxes were overlapped with the largest diameter on the top and the smallest on the bottom; one last box had no holes and was placed to collect the fruits with a diameter inferior to 20 mm. After the fruits were placed in the top box the boxes were stirred one by one as separation was occurring by the diameter of the fruits according, to the method proposed by Fernandes *et al*. (2007).

The proportion of fruits obtained in each diameter class and commercial production per ha^{-1} were evaluated. Data were subjected to analysis of variance, and when significant by the F test ($p < 0.05$), for the factor genotype the means were compared by the Tukey test ($p < 0.05$) and for the factor spacing adjusted to polynomial regression equations ($p < 0.05$).

Results and Discussion

The factor genotype significantly influenced all evaluated traits ($p < 0.05$), whereas the spacing factor had no significant influence. A significant interaction was verified ($p < 0.01$) in relation to the proportion of fruits with a diameter greater or equal to 30 mm and less than 35 mm ($30 \geq \varnothing < 35$). The CH 152 genotype had the highest proportion of fruit with diameter less than 20 mm ($\varnothing < 20$), and with a diameter between 20 mm and less than 25 mm ($20 \geq \varnothing < 25$) (Tables 1 and 2); in this genotype the fruit production did not reach the commercial standard according to the method proposed by Fernandes *et al*. (2007). This feature may be justified by the pear shape of the fruits of this genotype, which have irregular diameters in relation to the proposed classification, not discounting this as a potential genotype for commercial fruit production following other forms of classification such as weight, which was another classification proposed by Fernandes *et al*. (2007).

Table 1. Mean values of the proportion (%) of fruits of three tomato genotypes with diameter less than 20 mm ($\varnothing < 20$), as a function of spacing. Montes Claros, UFMG, 2010.

Genotype	Spacing (m)				
	(1.0 x 0.40)	(1.0 x 0.60)	(1.0 x 0.80)	(1.0 x 1.0)	Mean
CLN1561A	0.00	0.00	0.00	0.00	0.00 b
CH152	44.96	49.05	36.69	46.03	44.18 a
Carolina	0.91	0.33	5.19	1.77	2.05 b
Mean	15.29	16.46	13.96	15.93	

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

Table 2. Mean values of the percentage (%) of fruits of three tomato genotypes with diameter greater or equal to 20 mm and less than 25 mm ($20 \geq \varnothing < 25$), as a function of spacing. Montes Claros, UFMG, 2010.

Genotype	Spacing (m)				
	(1.0 x 0.40)	(1.0 x 0.60)	(1.0 x 0.80)	(1.0 x 1.0)	Mean
CLN1561A	0.00	0.12	0.00	0.00	0.00 b
CH152	44.31	50.94	63.30	53.96	53.12 a
Carolina	41.43	43.60	46.39	54.97	46.59 a
Mean	28.58	31.55	36.56	36.31	

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

The greatest proportion of fruit with a diameter between 25 mm 30 mm ($25 \geq \varnothing < 30$), was observed in the Carolina genotype, with an average of 49.58% of fruits (Table 3). Genotype CLN1561A stood out because all the fruit produced was of commercial standard, even surpassing the commercial variety Carolina.

Studying the pattern of commercial fruits of two other varieties of cherry tomatoes, Chadwick Cherry and Red Pitanga, also grown organically in Montes Claros MG, Toledo *et al*. (2011) reported similar results, since the highest percentages of fruit classified were grouped in the classes of diameter greater or equal to 35 mm ($\varnothing \geq 35$) and greater or equal to 30 mm and less than 35 mm. The variety Chadwick Cherry produced 91.6% commercial fruits, followed by the variety Red Pitanga, which had 80.4% of the fruits within the commercial standard.

A greater proportion of fruit with a diameter greater or equal to 30 mm and less than 35 mm ($30 \geq \varnothing < 35$) was observed in CLN1561A genotype at all spacings (Table 4). The largest proportion of marketable fruits for this genotype may be explained by the morphological appearance of the fruit, which are oblong shaped and generally with a diameter exceeding 25 mm. In the diameter class greater than or equal to 35 mm ($\varnothing \geq 35$) the CLN1561A genotype showed the highest proportion of fruits, while in the diameter class between 30 and 35 mm ($30 \geq \varnothing < 35$) the genotype CLN1561A had the highest proportion, regardless of the spacing (Tables 4 and 5).

As for total fruit yield (PT) and total commercial production (PCT), according to the classification for cherry tomato, the genotypes CLN1561A and Carolina stood out for having the greatest averages (Tables 6 and 7). Even without the occurrence of the interaction effect for total productivity the genotype and spacing were significant, where the genotypes CLN1561A and Carolina presented statistically equal productivity values, 8.52 and 7.45 t ha^{-1}, respectively (Table 8). Silva *et al*. (2011) evaluated the genotype CLN1561A along with other heat tolerant genotypes and obtained a greater productivity, reaching 27.13 t ha^{-1} planted at a spacing of 0.5 x 1.0 m. This greater productivity can be explained by the fact that the acreage of the experiment had been grown in the previous two years under organic fertilization and also because of the amendment made with calcinated bone meal, rich in phosphorus

Table 3. Mean values of the percentage (%) of fruits of three tomato genotypes with diameter greater than or equal to 25 mm and less than 30 mm ($25 \geq \varnothing < 30$), as a function of spacing. Montes Claros, UFMG, 2010.

Genotype	Spacing (m)				
	(1.0 x 0.40)	(1.0 x 0.60)	(1.0 x 0.80)	(1.0 x 1.0)	Mean
CLN1561A	5.00	8.92	4.50	12.40	7.70 b
CH152	10.72	0.00	0.00	0.00	2.68 b
Carolina	56.97	49.73	48.41	43.24	49.58 a
Mean	24.23	19.55	17.63	18.54	

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

Table 4. Mean values of the percentage (%) of fruits of three tomato genotypes with diameter greater or equal to 30 mm and less than 35 mm ($30 \geq \varnothing < 35$) as a function of spacing. Montes Claros, UFMG, 2010.

Genotype	Spacing (m)				
	(1.0 x 0.40)	(1.0 x 0.60)	(1.0 x 0.80)	(1.0 x 1.0)	Mean
CLN1561A	73.49 a	69.11a	80.72 a	70.65 a	73.49
CH152	0.00 b	0.00 c	1.06 b	1.06 b	0.53
Carolina	1.74 b	6.33 b	1.06 b	0.00 b	2.28
Mean	25.07	25.14	27.61	23.90	

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

Table 5. Mean values of the percentage (%) of fruits of three tomato genotypes with diameter greater or equal to 35 mm (∅ ≥ 35), as a function of spacing. Montes Claros, UFMG, 2010.

Genotype	Spacing (m)				
	(1.0 x 0.40)	(1.0 x 0.60)	(1.0 x 0.80)	(1.0 x 1.0)	Mean
CLN1561A	21.50	23.03	15.84	18.01	19.59 a
CH152	0.00	0.00	0.00	0.00	0.00 b
Carolina	0.00	0.00	0.00	0.00	0.00 b
Mean	7.16	7.67	5.28	6.00	

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$) probability.

Table 6. Mean values of the percentage (%) of marketable fruits (PCT) of three tomato genotypes, as a function of spacing. Montes Claros, UFMG, 2010.

Genotype	Spacing (m)				
	(1.0 x 0.40)	(1.0 x 0.60)	(1.0 x 0.80)	(1.0 x 1.0)	Mean
CLN1561A	100.00	100.00	100.00	100.00	100.00 a
CH152	55.03	50.94	63.30	53.96	55.80 b
Carolina	99.08	99.66	94.81	98.22	97.94 a
Mean	84.70	83.53	86.03	84.06	

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

Table 7. Mean values of total production (PT) per plant of three tomato genotypes in g^{-1}, as a function of spacing. Montes Claros, UFMG, 2010.

Genotype	Spacing (m)				
	(1.0 x 0.40)	(1.0 x 0.60)	(1.0 x 0.80)	(1.0 x 1.0)	Mean
CLN1561A	493.58	522.62	574.50	588.50	544.80 a
CH152	364.50	225.25	179.75	274.25	260.93 b
Carolina	576.25	429.33	363.25	440.58	452.35 a
Mean	478.11	392.40	372.50	434.44	

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

Table 8. Mean values of total fruit yield of three tomato genotypes in $t.ha^{-1}$, as a function of spacing. Montes Claros, UFMG, 2010.

Genotype	Spacing (m)				
	(1.0x 0.40)	(1.0 x 0.60)	(1.0 x 0.80)	(1.0 x 1.0)	Mean
CLN1561A	12.33	8.70	7.18	5.88	8,52 a
CH152	9.11	3.75	2.24	2.74	4,46 b
Carolina	14.40	6.50	4.53	4.40	7,45 ab
Mean	11.94	6.31	4.65	4.34	

Means followed by the same letter do not differ significantly by the Tukey test ($p < 0.05$).

and calcium that are elements strongly required by the tomato crop. Riahi *et al*. (2009), evaluating the effects of organic and conventional tillage systems on the yield and quality of four cultivars of tomato in Tunis, obtained results in which the conventional tillage system provided greater productivity and production among the evaluated cultivars. However the authors stress that the superior results of the conventional system in comparison with the organic system may be due to the fact that the experimental area used in the experiment had never been cultivated with an organic system, demonstrating that an area of organic farming may need successive crop plantings to achieve a level of fertility that can sustain similar or superior yields to the conventional cultivation. The conclusions of Riahi *et al*. (2009), help to explain the lower productivity of genotype CLN1561A compared to the yield obtained by Silva *et al*. (2011).

Evaluating the effect of spacing, a linear decrease in productivity was noted (Figure 1). This result is due to lower plant density, which resulted in lower fruit production per area, whereas with increasing density there was an increase in fruit production per area, corroborating the results of the work of other authors with tomato crops (Carvalho and Tessarioli Neto, 2005; Machado *et al*., 2007; Mueller and Wamser, 2009). Increasing productivity per area unit can be justified not only by the increase in plant population, but also by improving the use of available resources to the plants. Silva *et al*. (2001), working with dense tomato cultivation under different nutrient concentrations, concluded that the density of the crop improves the efficiency of the use of phosphate fertilizers by plants. Studying the effect of density on the yield of tomato hybrids, Carvalho and Tessarioli Neto (2005) concluded that increased density of plants increased the ability of the canopy tp intercept available solar radiation, so that the highest yields were obtained at denser spacings. According to studies by Flesch and Vieira (2004), increased plant density allows better use of the area under cultivation, better ground cover, greater potential for competition with weeds for resources and in relation to those factors, higher yields per cultivated area.

For the cherry tomato, adoption of higher planting densities would not affect the quality of fruits, as these are smaller and characteristic of this type of tomatoes. To make cherry tomato cultivation feasible it is recommended to growers to plant at the 0.4 x 1.0 m spacing, since this results in greater productivity per area.

Conclusions

Genotype CLN1561A excelled for having a higher proportion of marketable fruits per plant and per area, with promising characteristics for cultivation in an organic system.

Genotype CH152 stood out in the production of unmarketable fruits according to classification, one needs to conduct more studies on the pear shaped cherry tomato classification.

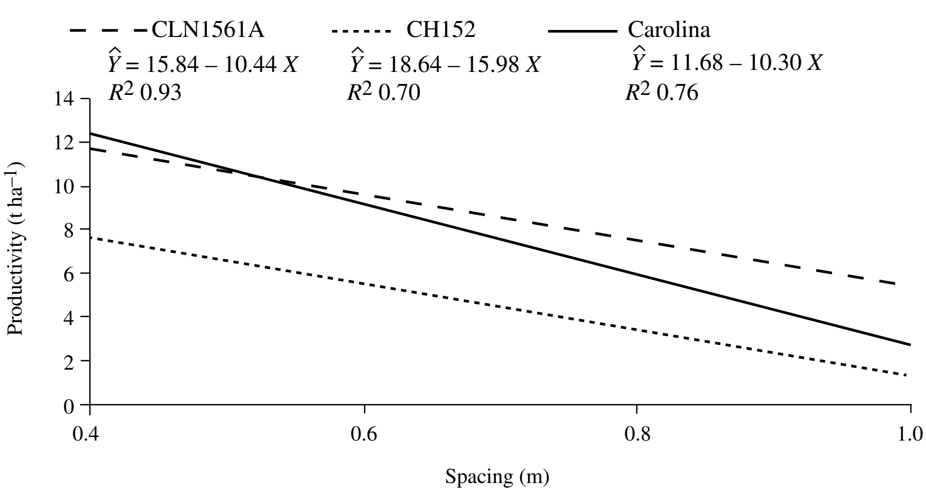

Figure 1. Productivity of tomato genotypes as a function of spacing. Montes Claros, UFMG, 2010.

The Carolina genotype, although showing the second best average proportion of commercial fruits, still is a very promising genotype for the region, as this is a variety of commercial cultivation facilitated by the availability of a greater supply of seeds for purchasing.

It is recommended to adopt spacing of 0.4 x 1.0 m, since this results in greater productivity per area.

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