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Production and quality of tomato fruits under organic management

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ABSTRACT

Information about the production and quality of tomato cultivars under organic management and the conditions of climate and soil from the north region of Minas Gerais State, Brasil, are scarce. Thus, this research was carried out to evaluate the production and quality of tomato cultivars under organic management, in this region. The treatments consisted of four open pollination tomato cultivars (Chadwick Cherry, Pitanga vermelha, Santa Clara and Santa Cruz Kada) and five hybrid cultivars (Marguerita, Nicolas, Ellen, Magestade and Dominador). The experimental design was of randomized blocks with three replications. The experiment was carried out using organic fertilization in the initial preparation of the area, compost and rock phosphate and sprays with Bordeaux mixture, neem oil and fertilizer. The marketable yield varied from 12.3 t ha^{-1} to 23.9 t ha^{-1}. The hybrid Marguerita presented higher marketable production (23.9 t ha^{-1}). The cultivars Chadwick Cherry and Pitanga Vermelha reached similar production as most cultivars and larger proportions of marketable and giant fruits, and therefore, better market quality. All the cultivars presented low potassium and manganese levels in foliar tissue suggesting an evaluation after various organic manuring cycles and better nutrition conditions are necessary to permit the comparison of the performance of cultivars in this system.

Keywords: *Lycopersicon esculentum*, organic cropping, green manure.

RESUMO

Produção e qualidade dos frutos de cultivares de tomateiro, sob manejo orgânico

Informações sobre a produção e qualidade de frutos de cultivares de tomateiro, sob manejo orgânico, nas condições de clima e solo do Norte de Minas Gerais, Brasil, são escassas. Por isso, o objetivo deste trabalho foi avaliar a produção e qualidade de frutos de cultivares de tomateiro, sob manejo orgânico, em Montes Claros-MG. Os tratamentos consistiram de quatro cultivares de tomate de polinização livre (Chadwick Cherry, Pitanga Vermelha, Santa Clara e Santa Cruz Kada) e cinco cultivares híbridos (Marguerita, Nícolas, Ellen, Majestade e Dominador). Foi utilizado o delineamento experimental em blocos casualizados, com três repetições. O experimento foi conduzido utilizando adubos verdes no preparo inicial da área, composto orgânico e fosfato natural no plantio, composto orgânico na amontoa, e pulverização com calda bordalesa, óleo de nim e biofertilizante. As médias de produção comercial das cultivares variaram de 12,3 t ha^{-1} a 23,9 t ha^{-1}. O híbrido Marguerita se destacou com maior produção comercial (23,9 t ha^{-1}). As cultivares Chadwick Cherry e Pitanga Vermelha atingiram produção semelhante à maioria das cultivares testadas e maiores proporções de frutos comerciais e da classe gigante e grande, portanto, melhor padrão de mercado. Todas as cultivares apresentaram baixos teores de potássio e de manganês no tecido foliar. Por isso, uma avaliação após vários ciclos de adubação orgânica, em condições mais favoráveis de nutrição, ainda é necessária para a comparação plena do desempenho das cultivares nesse sistema.

Palavras-chave: *Lycopersicon esculentum*, produção orgânica, adubos verdes.

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The State of Minas Gerais is the third largest tomato producer in the country, with 552 thousand tons in 8.000 ha cultivated, with an average yield of 68 t ha^{-1} (FAOSTAT, 2008; IBGE, 2008). Tomato is also one of the main products of organic agriculture in Brazil (Yamamoto, 2007). The market of organic products is driven by demand from consumers concerned about health issues and environmental preservation (Tamiso, 2005; Valarini *et al*., 2007; Yamamoto, 2007). Valarini & Resende (2007) cite that the organic production system for vegetables presents a better environmental performance than the conventional system, since it improves the conservation of natural resources, and, also, improves water quality.

Among the factors which hamper the production of organic tomato and the expansion of this trade are the lack of cultivars developed specifically for the organic system (Tamiso, 2005), the shelf life difference among organic and conventional tomato (Ferreira, 2004) and the susceptibility of the crop to pests and pathogens (Souza, 2003; Tavares, 2006).

Some publications have reported tomato yield values in organic system (Vargas *et al*., 2004; Souza, 2005; Tamiso, 2005; Tavares, 2006; Luz *et al*.,

2007; Zuba, 2007), and the average yield in this system is lower than the yield obtained in the conventional system. According to Ferreira *et al*. (2005), the organically cultivated tomato tends to present higher rate of small fruits in comparison to the conventional system. However, Souza (2003) emphasizes that the levels of organic productivity, to be considered viable or not, must take into account the costs generated by the activity and the price obtained for the product on the market. The production of organic tomato, when compared to the conventional production, presented a cost 17.1% lower and a profitability 113.6% higher. Furthermore, consumers of organic products accept non-standard fruits with different shapes and colors and are willing to pay more for them (Luz *et al*., 2007).

According to Peixoto *et al*. (1999a), the evaluation of cultivars within the same soil and climatic conditions allow to compare them as to their potential for productivity, fruit quality and resistance to pests and diseases. Different regions present different suitability to the cultivars, since they present diverse genetic traits that determine greater or lesser sensitivity to environmental conditions and other factors of production. Thus, the evaluation of cultivars in each region is essential for the selection of the most suitable ones.

In this context, this paper aimed at evaluating yield and quality of fruits from tomato cultivars in the organic production system under the summer conditions in Montes Claros, Minas Gerais State, Brazil.

MATERIAL AND METHODS

The experiment was carried out from July 2007 to May 2008 in an area with loam Cambisol, at the Universidade Federal de Minas Gerais, in Montes Claros, Minas Gerais State. The climate, according to the Koppen classification, is Aw, considered as tropical of savannah, with dry winter and rainy summer. The soil chemical analysis at 0-20 cm depth resulted: pH in water = 6.4, P= 2.9 mg dm^{-3}, K= 57 mg dm^{-3} (Mehlich 1), Ca= 6.2 $cmol_c$ dm^{-3}, Mg= 1.9 $cmol_c$ dm^{-3}, Al= 0 $cmol_c$ dm^{-3} (Extractor KCl 1 mol L^{-1}), sum of bases = 8.15 $cmol_c$ dm^{-3} (extractant calcium acetate 0.5 mol L^{-1}, pH 7.0), cation exchange capacity (t) = 8.15 $cmol_c$ dm^{-3}, cation exchange capacity (T) = 10.74 $cmol_c$ dm^{-3}; saturation of bases = 76% and organic matter content = 2.00.

The treatments were four open pollinated tomato cultivars (Chadwick Cherry, Pitanga Vermelha, Santa Clara and Santa Cruz Kada) and five hybrids (Marguerita, Nicolas, Ellen, Majesty and Ruler). A randomized block design, with three replications was used. In July 2007, the area was previously cultivated with a mixture of green manures: Sunn hemp (*Crotalaria juncea*), *Raphanus sativus*, oat (*Avena sativa*), velvet bean *Stizolobium aterrimum*, jack beans (*Canavalia ensiformis*) and Italian Ryegrass (*Lolium multiflorum*). The green manure seeds were mixed and broadcast sown in the rate of 100 kg ha^{-1}. When about 50% of plants were flowering, the area was mowed and plant material was left on the soil until planting the main crop. Pits were open, in which compost and rock phosphate were incorporated (Table 1). The compost was prepared with cattle manure, cotton waste and rice husk. Tomato was planted in February 2008 in plots with 28 plants, of them, 10 plants consisted the useful plot. The spacing was 0.5 m between plants and 0.9 m between rows. Plants were grown with one stem in the vertical system with ribbon. The earth up was performed using organic compost. Side pruning was carried out from 30 days after transplanting and apical pruning, after the growth of the sixth bunch.

For prevention of pests and diseases, spraying was made during the crop cycle, with Bordeaux mixture 1%, neem oil (*Azadirachta indica*) 0.5%, which was acquired in the local market, and biofertilizer in concentrations ranging from 2 to 10%. Bordeaux mixture was prepared by dissolving copper sulfate and lime in water. The liquid biofertilizer was produced by anaerobic fermentation of a mixture of water, cattle manure, raw milk, sugar and micronutrients (copper sulphate, magnesium sulphate, zinc sulphate and boric acid) (Mesquita, 2005). During fruiting, biological control of pest-insect eggs was carried out with *Trichogramma pretiosum*, through the release of a population of 100,000 individuals per hectare each 15 days.

To analyze the content of macronutrients and of the micronutrients Zn, Fe, Mn and Cu, leaf samples were collected in each plot. The leaf sample was the leaf opposite to the third cluster of flower, collected 50 days after planting. For each cultivar, a composite sample was formed with the replications. The samples were dried in forced circulation at 72°C to constant mass.

At harvests, the following traits were evaluated: average number of racemes, total yield, marketable yield, rate of marketable yield, rate of fruits identified according to the type of damage (pathogen, pest insect and physical damage (Bacci *et al*., 2006) and rate of fruits in each size class, following the Brazilian standards for tomato classification (Brasil, 1995; Brasil, 2002).

The cultivars of round fruits were classified according to fruit diameter in giant (>10 cm), large (>8-10 cm), medium (>6.5 to 8 cm) and small (>5 to 6.5 cm). The oblong fruit cultivars were classified according to the diameter of the fruit into large (>6 cm), medium (>5-6 cm) and small (>4-5 cm) (Brasil, 2002). The cultivars of fruits of the cherry type, Chadwick Cherry and Pitanga Vermelha, were classified according to fruit diameter in giant (>3.5-4 cm), large (>3-3.5 cm), medium (>2.5-3 cm) and small (>2-2.5 cm).

Data were subjected to analysis of variance trough the F test, considering the randomized block design. Means were compared by the Scott-Knott test at 5%.

RESULTS AND DISCUSSION

Significant difference was observed for all traits of the cultivars (Tables 2 and 3), and Chadwick Cherry and Pitanga Vermelha produced the highest numbers of racemes. These cultivars produce fruits with lower average weight and have the tendency to produce

Table 1. Supply of macronutrients in the experimental area in the form of compost (fornecimento de macronutrientes na área experimental na forma de composto orgânico). Montes Claros, UFMG, 2008.

Source of nutrients	P_2O_5	N	K_2O	CaO	MgO
	kg ha^{-1}				
Compost(1)	338	374	644	994	481
Natural phosphate(2)	775	nd	nd	840	nd
Total (kg ha^{-1})(3)	1113	374	644	1834	481
Recommendation (kg ha^{-1})4	900- 1200	100-400	200 - 600	-	-

[1]Compost supplied in the planting plus covering (1050 g per hollow); [2]Fertilizer with 29% of P_2O_5 and 35% of CaO (120 g per hollow); [3]Total nutrient, except nutrients supplied through the biofertilizante and Bordeaux mixture; [4]Recommendation of macronutrients, according to Filgueira *et al*. (1999) ([1]Quantidades de composto fornecido no plantio e na cobertura (1050 g/cova), calculado baseado na análise de nutrientes do composto; [2]Adubo com 29% de P_2O_5 e 35% de CaO (120 g por cova); [3]Total de nutrientes, exceto aqueles fornecidos pelo biofertilizante e pela calda bordalesa; [4]Recomendação de macronutrientes, segundo Filgueira *et al*. (1999)).

Table 2. Number of racemes, production (t ha^{-1}), marketable production (t ha^{-1}) and marketable fruits (%) of tomato cultivars under organic management (número de racemos, produção (t ha^{-1}), produção comercial (t ha^{-1}) e frutos comerciais (%) de cultivares de tomateiro, sob manejo organico). Montes Claros, UFMG, 2008.

Cultivars	Racemes per plant	Yield (t ha^{-1})	Commercial yield (t ha^{-1})	Commercial fruits (%)
Chadwick Cherry	6.00 a	15.05 a	14.10 b	91.6 a
Pitanga Vermelha	6.30 a	19.49 a	16.75 b	80.4 b
Marguerita	5.00 b	28.48 a	23.94 a	65.0 c
Santa Clara	3.90 b	16.60 a	14.09 b	62.1 c
Santa Cruz Kada	4.00 b	13.91 a	12.31 b	53.0 d
Nícolas	4.30 b	15.82 a	12.44 b	49.7 d
Ellen	5.20 b	20.55 a	15.12 b	49.5 d
Dominador	4.90 b	19.70 a	13.85 b	46.4 d
Majestade	4.80 b	17.99 a	13.85 b	44.6 d
CV (%)	13.41	23.04	23.03	9.05

Médias seguidas da mesma letra nas colunas não diferem entre si pelo teste de Scott-Knott a p<0,05 (averages followed by the same small letter in the column do not differ by the Scott-Knott test at 5% probability).

greater numbers of racemes and fruits (Giordano *et al*., 2005; Costa *et al*., 2006) (Table 2).

Nevertheless, according to the Scott-Knott test, there was no difference among cultivars in relation to total production (Table 2) and the average production was 15.2 t ha^{-1}. Regardless the production system, comparison among hybrids and/or traditional cultivars such as Santa Clara and Santa Cruz is common, and, generally, presents significant differences in the mass of marketable fruits and average fruit weight, as reported in the papers of Peixoto *et al*. (1999b), Eklund *et al*. (2005) and Gualberto *et al*. (2007) in the conventional production system. In these works, the production of hybrid and traditional cultivars such as Santa Clara and Santa Cruz showed no significant differences in fruit production, but showed difference in the production of marketable fruits. According to these authors, the difference in the production of marketable fruits is due to the difference in tolerance of cultivars to the attack of insect pests and pathogens.

The average marketable yield of the cultivars ranged from 12.3 t ha^{-1} to 23.9 t ha^{-1} and the hybrid Marguerita presented the highest value, which was related to a high productivity associated to a lower fruit loss due to injuries of pests and diseases in comparison to the other hybrids. Although the cultivars Chadwick Cherry and Pitanga Vermelha produce fruits of the cherry type, their yield was similar to most large-fruit cultivars (Table 2). This was mainly due to lower loss of fruits due to attack of pests and diseases, presented by these cultivars.

Tamiso (2005) evaluated the production of tomato cultivars under organic management in a greenhouse, driving one single stem and adopting drastic apical pruning. That author obtained marketable yields ranging from 11.34 t ha^{-1} to 38.10 t ha^{-1}, with the highest productivity obtained with a hybrid.

The average marketable yield of cultivars was close to that obtained by other authors. Zuba (2007) also studied the cultivar Santa Clara during the summer, in Montes Claros, Minas Gerais State, and obtained marketable yield of 19.3 t ha^{-1} with organic fertilization. In the study of Souza (2005) in organic cultivation, yields were higher than the obtained in this experiment, but several cycles of cultivation were necessary to improve soil fertility through the use of green manure and organic residue and to reach a balance between the population of pests and natural enemies.

The cultivar Chadwick Cherry presented the highest proportion of marketable fruits followed by the cultivar Pitanga Vermelha (Table 2). 'Chadwick Cherry' and 'Pitanga Vermelha' are known as "heirloom", or traditional cultivars used in organic system in regions of the United States of America, for its rusticity and adaptability to climates ranging from extreme cold to hot. Through the evaluation of fifty "heirloom" tomato cultivars from Europe and the United States in greenhouse under organic management, Vargas *et al*. (2004) obtained fruits of good sanity and quality, with approximately 80% of marketable fruits. This proportion of marketable fruit

Table 3. Damage of fruits (%) depending on six factors in tomato cultivars under organic management (Danos em frutos (%), em função de seis fatores em cultivares de tomateiro, sob manejo orgânico). Montes Claros, UFMG, 2008.

Cultivar	*Diabrotica speciosa*	*Neoleucinodes elegantalis*	*Erwinia carotovora*	Leaf curl	Cracking	Not commercial size
Dominador	10.24 Ab	1.60 Ac	6.36 Ab	9.79 Ab	0.00 Ac	27.30 Ba
Santa Clara	7.01Ab	1.06 Ac	8.37 Ab	0.79 Bc	0.00 Ac	19.50 Ba
Pitanga Vermelha	2.79 Ab	1.26 Ab	10.18 Aa	0.00 Bb	1.47 Ab	0.00 Cb
Santa Cruz Kada	6.13 Aa	0.83 Ab	9.03 Aa	6.10 Bb	0.00 Ab	18.32 Ba
Nícolas	6.37 Ac	1.38 Ac	14.10 Ab	1.78 Bc	1.35 Ac	26.16 Ba
Ellen	8.52 Ab	2.84 Ab	5.80 Ab	0.55 Bc	0.00 Ac	26.20 Ba
Marguerita	4.79 Ab	0.95 Ab	4.26 Ab	0.71 Bb	1.65 Ab	23.20 Ba
Majestade	6.41 Ab	2.06 Ac	4.42 Ab	2.02 Bc	0.39 Ac	40.44 Aa
Chadwick Cherry	2.69 Aa	2.98 Aa	1.69Aa	0.42 Ba	2.27 Aa	0.14 Ca
CV (%)			47.50			

Means followed by the same uppercase letter in the columns and by the lowercase letter in the rows do not differ according to Scott-Knott test at the 5% level of probability (Médias seguidas pela mesma letra maiúscula nas colunas ou minúscula nas linhas não diferem entre si pelo teste de Scott-Knott a p<0,05).

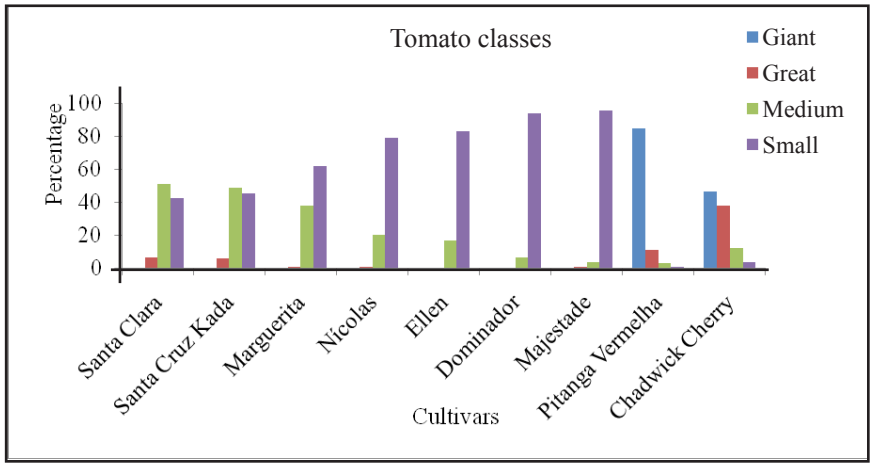

Figure 1. Distribution in classes of size of tomato fruits according to standards for fresh and cherry tomato under organic management (distribuição percentual das classes de tamanho dos frutos de cultivares de tomateiro classificados de acordo com os padrões de tomate para mesa e de tomate cereja, sob manejo orgânico). Montes Claros, UFMG, 2008.

is very close to the obtained with the cultivars Chadwick Cherry and Pitanga Vermelha. Nevertheless, the common cultivars and the hybrids produced a lower proportion of marketable fruits due to the attack of pests and pathogens and the production of unmarketable fruits (Table 3).

Approximately 50% of the production of the cultivars Santa Cruz Kada, Ellen, Dominador, Majestade and Nicolas was composed of damaged fruits by injury or pests and diseases or fruits out of the commercial standard (Table 3). Probably, this loss in production is due to the fact that the cultivation was the first year of organic farming, where the environment is still not balanced with respect to the solubilization of nutrients and control of pests and diseases, and the factors inherent to the cultivars, such as lower resistance to pests and diseases. Several authors have reported significant losses in production of tomatoes and other vegetables related to the attack of pests and pathogens, even in a conventional system (Loos *et al*., 2004; Bacci *et al*., 2006).

As for fruit size, the hybrids evaluated were classified as round fruits, because they had transverse diameter greater than or equal to the longitudinal diameter. The fruits of the cultivars Santa Cruz Kada and Santa Clara were classified as oblong, since they present transversal diameter smaller than the longitudinal. The fruits of cultivars Chadwick Cherry and Pitanga Vermelha were classified following the standards for cherry tomatoes.

The cultivars Chadwick Cherry and Pitanga Vermelha yielded the highest percentage of giant and large fruits, 'Santa Clara', 'Santa Cruz Kada' and 'Marguerita' yielded the highest percentage of medium fruits and the hybrids Majestade, Dominador, Nícolas and Ellen yielded the highest percentage of small fruits. In general, according to the classification, there was a higher proportion of small fruits among the hybrids (Figure 1).

All cultivars except Chadwick Cherry and Pitanga Vermelha presented the highest percentage of loss of fruits due to unmarketable size, confirming that the organic tomato does not fit the quality standard for the conventional tomato (Ferreira *et al*., 2005) (Table 3).

All cultivars had average levels of 1.5% K and 30 mg kg^{-1} of Mn in the leaf tissue, below the reference values of Boaretto *et al*. (1999). Therefore, an evaluation after several cycles of organic fertilization under a more favorable condition of nutrition is still necessary for the full comparison of the performance of cultivars in this system.

There are differences in yield and fruit quality among the evaluated

cultivars. 'Chadwick Cherry' and 'Pitanga Vermelha' reached yield similar to that of most evaluated cultivars and better quality of fruits. Therefore, they presented a greater performance in the adopted system.

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