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Mineral composition of pulp and production of the yellow passion fruit with organic and conventional fertilizers

Anália Lúcia Vieira Pacheco [a], Mateus Francisco Pagliarini [a], Gilberto Bernardo de Freitas [a], Ricardo Henrique Silva Santos [a], José Eduardo Serrão [b], José Cola Zanuncio [c,*]

[a] Departamento de Fitotecnia, Universidade Federal de Viçosa, 36570-000 Viçosa, Minas Gerais, Brazil
[b] Departamento de Biologia Geral, Universidade Federal de Viçosa, 36570-000 Viçosa, Minas Gerais, Brazil
[c] Departamento de Entomologia, Universidade Federal de Viçosa, 36570-000 Viçosa, Minas Gerais, Brazil

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ABSTRACT

The use of organic foods has been increased in the world. Organic fertilizers, like cattle manure, have emerged as an important component of the organic system production. The production, mass, size, and mineral composition of passion fruit pulp were evaluated when treated with a mineral fertilizer (control) (MIN) or cattle manure at a single dose equivalent to potassium fertilizer (ORG) or double dose (2×ORG). The production and the numbers of fruits of plants treated with MIN and 2×ORG was higher than with ORG. The level of nitrogen (N), phosphorus (P), zinc (Zn), iron (Fe), and copper (Cu) in the fruit pulp was similar with all three fertilizers, but the calcium (Ca) and magnesium (Mg) was higher with ORG and 2×ORG. The number and weight of the fruits of passion fruit treated with 2×ORG were similar to those with MIN fertilizer, but they contained more Ca and Mg.

1. Introduction

Organic foods are healthier than conventionally produced foods and its production approaches are more environmentally compatible (Pérez-López, López-Nicolás, & Carbonell-Barrachina, 2007). However, consumers' expectations must be properly demonstrated by scientific studies. The antioxidant activity of tropical fruits such as sweet passion fruit, its mineral composition (de Souza, Pereira, Queiroz, Borges, & Carneiro, 2012), and differences between the volatile compounds in the pulp of passion fruit grown in organic and conventional management systems has been studied in Brazil.

Plant nutrition is a bottleneck in organic or sustainable agriculture, with a constant search for alternatives to substitute the use of mineral fertilizers (Cavalcante, Cavalcante, dos Santos, Beckmann-Cavalcante, & Silva, 2012; Maggio, De Pascale, Paradiso, & Barbieri, 2013). Mineral fertilizers have been used in global agriculture, but such fertilizers are expensive for smallholder agriculture, c.a. two billion people in developing countries (Garibaldi et al., 2016) and results in negative environmental impacts such as soil salinization (Cavalcante et al., 2012). Plant varieties resistant to insects and pathogens have been developed, but not plants able to cope with lack of nutrients, such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and others.

An ideal alternative fertilizer for organic agriculture does not exist because standards, such as those used in conventional agriculture (e.g. 20-05-20 N:P:K), have not been stablished. Some researchers have advocated the use of alternative fertilizers such as cattle manure (Pires et al., 2008), biofertilizers (Cavalcante et al., 2012) and poultry manure (Ani & Baiyeri, 2008). Moreover, the soil type, climatic factors, conversion time to organic farming, farm size, availability of these fertilizers, and labor, can affect organic agriculture. Therefore the quality of fruits or vegetables produced using organic or conventional fertilizers depends of interaction among those variables during the cycle production (Maggio et al., 2013; Reganold et al., 2010; Rosati et al., 2014). It is necessary improve the livelihoods of smallholder minimizing negative environmental impacts, achieving food security (Godfray et al., 2010).

Plant macronutrients nitrogen and potassium are required in a higher proportion by passion fruit plants, followed by Ca, sulfur (S), P, and magnesium (Mg) (Haag, Oliveira, Borducchi, & Sarruge, 1973). Manganese (Mn) is the most extracted micronutrient followed by iron (Fe), zinc (Zn), boron (B), and copper (Cu). However, the plant response to fertilizer is more dependent on the

* Corresponding author.
E-mail addresses: analia.pacheco@ufv.br (A.L.V. Pacheco), matpagliarini@gmail.com (M.F. Pagliarini), bernardo@ufv.br (G.B. de Freitas), jeserrao@ufv.br (J.E. Serrão), zanuncio@ufv.br (J.C. Zanuncio).

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interaction between nitrogen and potassium than these nutrients isolated (Malavolta, Vitti, & Oliveira, 1997).

The yield of yellow passion fruit is higher with a ratio of N:K1:2, and an inadequate N:K can cause the drop of passion fruits with externally green but ripe internally (Borges, Rodrigues, Lima, Almeida, & Caldas, 2003). Fertilizers affect the external passion fruit characteristics, such as, weight, size, and skin thickness, and internal characteristics, such as juice percentage, soluble solid content, and acid index (Aular, Casares, & Natale, 2014).

For seedling production of this plant as well as fruit yields (Ani & Baiyeri, 2008), exclusive use of organic compounds, such as cattle or chicken manure or supplementation with mineral fertilizers, is a reality. Cattle manure can be used by increase the plant nourishment and potassium available in the soil compared with mineral fertilizers (Pires et al., 2008).

The objective of this study was to evaluate the production, mass, size, and mineral composition of the fruit pulp from passion fruit produced using cattle manure. Passion fruits were fertilized with organic cattle manure and the fruit quality compared with those obtained from plants treated with mineral fertilizer.

2. Material and methods

2.1. Area characterization

The study was conducted at the Experimental Sowing Farm of the Universidade Federal de Viçosa (UFV), in the Visconde do Rio Branco city, Zona da Mata region of Minas Gerais State, Brazil with an average altitude of 360 m, 21°47′S latitude and 42°50′W longitude. According to the Köppen classification, the climate is rainy tropical savanna (Aw) with an average annual temperature of 21 °C, average rainfall of 1270 mm, and relative humidity of 80%.

Previously, the area was occupied by natural pasture but, in 2003, *Mucuna cinereum* was cultivated. No organic or chemical fertilizers were applied before the orchard deployment.

The area has yellow oxisoil, analysis of which showed the following chemical and physical characteristics at 0–20 and 20–40 cm deep, respectively. pH (H_2O) = 6.17 and 6.23; P = 4.73 and 2.97 $mg.dm^{-3}$; K = 14.58 $mg.dm^{-3}$ and 5.25; Ca^{+2} = 4.63 and 3.97 $cmolc.dm^{-3}$; Mg^{+2} = 1.60 and 1.60 $cmolc.dm^{-3}$; Al^{+3} = 0.00 and 0.00 $cmolc.dm^{-3}$; H + Al = 3.08 and 2.09 $cmolc.dm^{-3}$; SB = 6.32 and 5.62 $cmolc.dm^{-3}$; CTC(t) = 6.32 and 5.62 $comlc.dm^{-3}$; CTC (T) = 9.40 and 7.71 $cmolc.dm^{-3}$; V(%) = 67 and 73.

2.2. Species used, production, and seedling transplanting

The yellow passion fruit (*Passiflora edulis* Sim sf. *flavicarpa* Degener) was used throughout this study. Seedlings were produced from seeds taken from the first fruits with commercial characteristics (thin shell, high-yield pulp, and orange pulp), collected from vigorous and productive plants in the Experimental Sowing Farm. The fruits were collected between December 2003 and January 2004, and sowed in January 2004.

The seedlings were planted in the field at the end of March 2004, when they were 15–20 cm high. The spacing was 3.5 m between rows and 4.0 m between plants, with 714 plants ha^{-1}. Holes (50 cm diameter and 50 cm deep) were opened up with a mechanical auger and received in their preparation (filler), 10 L of cattle manure, thermo 500 g, and 200 g of dolomite lime each. Lime was distributed on the walls and bottom of the pit and thermo and cattle manure mixed with soil from the opening of the pit. After filling, the pit remained without use for about 30 days, after which the seedlings were planted. The seedlings were irrigated weekly during the dry season (April–August 2004), to enable its growth and establishment in the field.

2.3. Conduction system and cultivation

The orchard was planted in vertical position using a smooth wire, stuck and stretched by stakes, spaced 4–1.80 m height. The plants were conducted in a single stem, eliminating the side shoots, exceeding 20 cm above the driving wire, and their apical buds were eliminated, to stimulate the emergence of side shoots. Two opposing shoots nearer to the wire were selected and conducted on each plant side.

The apical meristem of each branch was eliminated when the lateral shoots reached 2 m in length, to induce the formation of the tertiary side branches, that is, productive.

Pruning was performed after the growth of tertiary branches to keep the final branches 40 cm from the ground.

Diseases and pests were monitored and controlled in the experimental area, where necessary, with products allowed in the organic production systems (syrups, plant extracts, biofertilizers, and commercial alternative pesticides) by the normative instruction n° 007 (BRASIL, 1999) and sprayed with Bordeaux mixture every two months, to prevent fungal diseases.

Invasive plants were managed, when necessary, with mechanical mowing and manual weeding between rows and in the rows.

2.4. Fertilizers

The plants were fertilized with cattle manure, in two doses, and the control had mineral fertilizers (ammonium sulfate, superphosphate, and potassium chloride). The amount of mineral fertilizers and manure per plant was based on soil fertility and chemical composition of the cattle manure (N = 1.85 $dag.kg^{-1}$; P_2O_5 = 1.72 $dag.kg^{-1}$; K_2O = 2.08 $dag.kg^{-1}$; Ca = 1.49 $dag.kg^{-1}$; Mg = 0.88 $dag.kg^{-1}$; S = 0.64 $mg.kg^{-1}$; Zn = 185.00 $mg.kg^{-1}$; Fe = 13630.00 $mg.kg^{-1}$; Mn = 493.30 $mg.kg^{-1}$; Cu = 38.90 $mg.kg^{-1}$; and B = 27.20 $mg.kg^{-1}$) and on the expected productivity (15–20 t ha^{-1}). This fertilization was divided four times during the rainy season (September 2004–April 2005), with an interval of approximately two months. The N:K of fertilizers used were: 1:2.25 for mineral fertilizer indicated for the culture, MIN; 1:1.12 for the ORG, and 2×ORG (twice the dose of cattle manure used in ORG).

2.5. Experimental design

The experiment was developed in a completely randomized design, with four replications and four plants per plot. The treatments were three fertilizers types: a mineral (MIN) as indicated for the culture representing the control; an organic (ORG), equivalent to potassium fertilization indicated for the culture, and (2×ORG), double the cattle manure dose used for the ORG fertilization.

The organic fertilizer was based on equivalence with the potassium fertilization, because this nutrient was the most exported by the fruits harvested and required in larger quantities (Borges et al., 2003; Haag et al., 1973).

The quantities were, for MIN: 140 g ammonium sulfate (AS), 105 g single superphosphate (SS), and 105 g of potassium chloride (KCl). The ORG and 2×ORG fertilizers were 12 and 24 L of cattle manure, respectively, applied per plant, in September and December 2004 and February and April 2005.

The amount of macro and micronutrients (g $plant^{-1}$) provided by the fertilizers for MIN, ORG, and 2×ORG were showed in Table 1.

2.6. Fruit harvest

The passion fruits were harvested from the plant, weekly, from the beginning of ripening (December 2004) when 30–40% of fruit