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Mineral and organic fertilizer in two *Physalis* species

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Physalis **cultivation can be an alternative of extra income for small and medium producers, mainly with the use of materials available on the property that can replace chemical fertilizer. This study aimed to evaluate agronomic parameters of *Physalis peruviana* and *P. pubescens* submitted two different sources of fertilization - chemical and organic. We evaluated plant height, shoot dry mass, production/plant, fruits diameter and weight and productivity. The organic fertilization provided better results for vegetative parameters. Regarding production, fertilization resulted in increase in mass, with no significant difference between sources. In the production of fruits/plant we obtained 156.2 g, 274.6 and 355.5 g for unfertilized, chemical and organic fertilizers, respectively, without significant differences between species. The productivity estimates were 2,370, 1,831 and 1,041 kg ha^{-1}, for organic, mineral and unfertilized treatments, respectively. These results demonstrate that organic fertilizer with poultry manure is the best alternative as a source of nutrients, which may result in gains to the producer by the use of originated waste from other activities, as well as lower environmental contamination, either by improper disposal of waste or the use of chemical fertilizers.**

Key words: Nitrogen, nutrition, poultry litter, production, Solanaceae

INTRODUCTION

The *Physalis* genus, belonging to the Solanaceae family, comprises about 120 species and its probable center of origin is the Mexico (Li et al., 2008; Kindscher et al., 2012; Whitson, 2012). Its fruits are protected by a capsule and contain significant levels of vitamins A, C and B complex, and minerals, carotenoids and tocopherols (Hassanien, 2011; Ramadan, 2011), with some of these with antioxidant activity (Bravo et al., 2015). It is noteworthy the production of polioxigenated metabolites, the vitasteroids, including physalins, which are substances that present interesting pharmacological activities (Tomassini et al., 2000). Some species are used in traditional medicine for treatment of diseases, with several studies demonstrating the presence of other bioactive molecules that can cause future, medications (Arun and Asha, 2007; Chen et al., 2011; Hassanien, 2011; Puente et al., 2011).

Physalis, although little known to the majority of consumers, has production and marketing potential, especially for its nutraceutical qualities (Barbieri et al., 2012), and may be an excellent alternative for small and medium producers (Thomé and Osaki, 2010). In Brazil,

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Table 1. Area soil testing results where the experiment was carried out.

MO (g dm^{-3})	P (mg dm^{-3})	K (cmol$_c$ dm^{-3})	Ca (cmol$_c$ dm^{-3})	Mg (cmol$_c$ dm^{-3})	pH $CaCl_2$	V (%)	Index SMP	SB (cmol$_c$ dm^{-3})	H+Al (cmol$_c$ dm^{-3})
34.85	23.44	0.70	4.53	1.78	4.60	58.56	6.00	7.01	4.96

Table 2. Results of the analysis of organic matter (poultry litter after weathering).

N (%)	P (%)	K (%)	Ca (%)	Mg (%)
2.65	1.50	2.29	2.25	0.51

Table 3. Amount of each fertilizer applied per plant.

Fertilizer	g plant^{-1}
Urea	95.0
Single superphosphate	311.1
Potassium chloride (KCl)	74.0
Poultry litter	1600.0

P. peruviana has been gaining attention among producers; however, are still scarce work and research results to guide them in relation to cultural practices, productivity and economic aspects of production. Currently, the fertilizer management carried out in Phyalis crops is based on recommendations for tomato crop (Gonçalves et al., 2012; Filgueira, 2003; Rufato et al., 2008). Differently from *P. peruviana, P. pubescens* is known by farmers to be considered weed (Lorenzi, 2008), and, therefore without major interest in the exploitation of its fruits.

The application of fertilizers and lime in the fruit production can represent over 25% of the production cost and, therefore, the use of organic compounds becomes a promising alternative (Vidigal et al., 2010). In addition, the use of organic fertilizer provides greater environmental sustainability, preserving natural resources, avoiding water contamination and harnessing materials available on the agricultural property, reducing production costs and making it feasible economically.

Based on the presented, the aim of this work was to evaluate agronomic parameters of two species of *Physalis* - *P. peruviana* L. and *P. pubescens* L. - submitted to mineral and organic fertilizer (poultry litter), with focus on nitrogen fertilization.

MATERIALS AND METHODS

Seeds of *P. peruviana* L. and *P. pubescens* L. were obtained from plants grown in a greenhouse. It was used 250 mL plastic cups with fertile humus as substrate to obtain the seedlings, setting three seeds in each one. The cultures were kept in a greenhouse, with average temperatures in the period of 24 °C, being carried manual waterings daily, in the early morning and late afternoon, avoiding waterlogging and/or water stress. After 20 days, was performed the thinning leaving one seedling cup. When the plants reached about 15 cm (50 days after sowing) were transplanted to the experiment site in spacing of 3,0 x 0,5 m. Each experimental unit consisted of 12 plants, and the borders were not used for evaluations. The crop treatment consisted of frequent waterings (manual) with soil kept in its field capacity, weed control (manual weeding), especially in the early stages and monitoring the emergence of pests and diseases. Once the plants reached 30 cm were vertically trained with the help of bamboo stakes.

The experiment was conducted within the municipal district of Itapejara D'Oeste/PR, located at 26°3'30.54" S and 52°48'7.06" O, altitude of 530 m, with the weather classified as Cfa (humid subtropical climate), according to Köppen. The average temperature during the execution of the experiment was 23.5°C (Data collected daily at the site of the experiment, with thermometer use. The soil was analyzed before the experiment installation (Table 1) and after correction, presented pH 5.8 and base saturation (V%) above 70%.

The two species of *Phyalis* received, each one, three treatments: control (without fertilizer), mineral fertilizer (NPK) and organic (poultry litter). For mineral fertilizers was used three different sources: urea (45% N), single superphosphate (18% P_2O_5) and potassium chloride (60% K_2O). The organic fertilization consisted of existing poultry litter on the property where the experiment was carried. This material was weathered for a period of 90 days before use, was submitted after it, to chemical analysis to determine nutrient content, as shown in Table 2.

Fertilization was performed in the pits at the time of transplanting, considering 300 kg of nitrogen per hectare. The nitrogen dose was based on trials in greenhouse (Passos, 2013). The amounts of phosphorus and potassium were calculated on the basis of the result of poultry litter analysis. The doses used are shown in Table 3.

The experimental design was a randomized blocks, with two species, three treatments and five blocks, characterized as a two-factor (2 x 3) with two qualitative variables, with 30 plots and each one with 12 plants.

The experiment was carried in the years 2013 and 2014 (from October 2013 to January 2014 having as previous experiment based on 2012 to 2013), and due to irregularity of production, was set up a unique collection of materials at 140 days after sowing. The following parameters were evaluated: plant height (cm), dry matter of aerial parts (DMAP) (g), fruit production per plant (g), average yield (kg ha^{-1}), transverse diameter (equatorial) average fruit (mm) and average fruit weight, with capsules (g). It was also estimated the relative increase in productivity arising nitrogen fertilization (IRPAN) proposed by Ferreira et al. (2010). For this, we used the difference between the maximum production fruit (MW) kg ha^{-1} and fruit production to a zero dose (PBC zero) divided by N rate required to obtain the PM by using the formula: IRPAN = (PM – PBC zero) / (Dose PM).

The data were submitted to analysis of variance (ANOVA) and the means analyzed by Tukey test at 5% probability of error, with GENES statistical program.

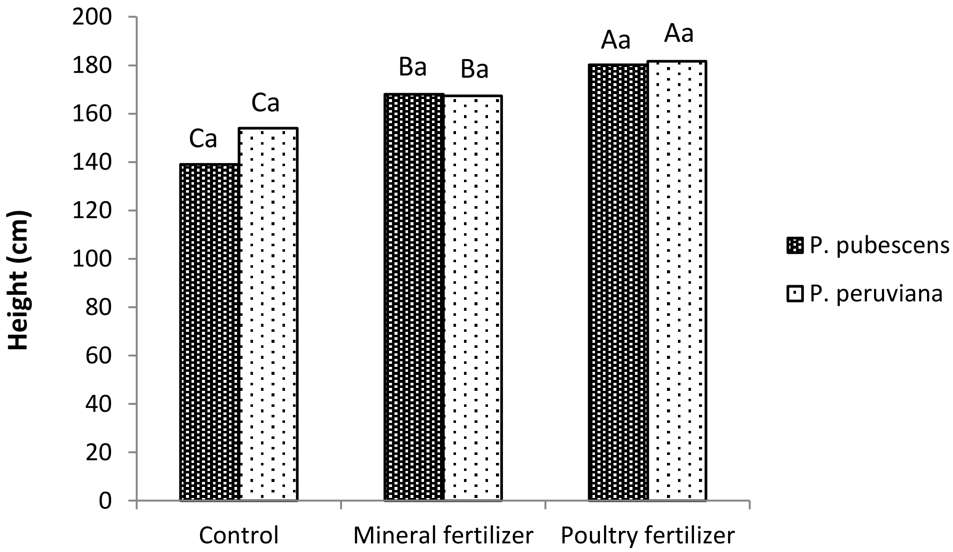

Figure 1. Final plant height (cm) of *Physalis*, under different nutritional

RESULTS AND DISCUSSION

The final plant height parameter showed no significant difference between species, however, there was significant difference between the nutritional sources. Fertilization providing higher height was organic, with an average of 180.90 cm main branch height, against 167.7 of mineral fertilizer (Figure 1).

Peixoto et al. (2010), using two doses of cattle manure, 30 and 60 t ha^{-1}, *Physalis (P. peruviana),* found no significant difference between them in plant height parameter, showing that although there is no influence of dose, probably the source was important. In tomato plants, the application of the effluent derived from the biodigestion of cattle manure resulted in higher plants (10.5%) compared to treatment with NPK (Campos, 2007). Freitas et al. (2012) also observed a better response in the rate of growth of sorghum plants when received organic manure (cattle manure). These authors suggest that plants under the organic fertilizer respond gradually over the growing cycle of the crop, once the nutrient release rate is not as fast as in the chemical fertilizer, supplying therefore their nutritional needs for a longer period chemicals, which could be observed in the same Physalis plants fertilized with poultry litter.

Unlike that observed for *Physalis*, some studies comparing organic and chemical fertilizers, such as jambu, the authors had greater heights when plants were treated with urea, and organic resulted in lower plants than the considered for the specie (Borges et al., 2013).

The dry matter of aerial parts (DMAP) showed the same pattern of plant height parameter. The organic fertilization resulted in better response, with an average of 1010.35 g of DMAP $plant^{-1}$, the mineral fertilizer 982.96 g DMAP $plant^{-1}$, and the control with the lowest value of 882.10 g DMAP $plant^{-1}$ (Figure 2).

Satisfactory results resulting from organic fertilization were found also in other species, such as basil, which in addition to chicken manure, received mineral complementation (Blank et al., 2005). Silveira Junior et al. (2015) reported an increase in Piata grass biomass using different doses of biofertilizers derived from the poultry manure digestion. Beyond merely supplying nutrients, the positive effects in the soil such as increased microbial activity, improved aeration and water infiltration in the soil profile, it provided better plant growth, resulting in the largest mass production with organic fertilizer, in the two species tested, in relation to controls and mineral fertilizer. The opposite was also observed in study about the influence of semi-decomposed poultry manure (10 t ha^{-1}) and mineral fertilizers (4.5 g m^{-2}), applied in coverage, in lettuce and peruvian carrot, in isolated crops or in consortium (Vieira et al., 2003). The authors obtained higher yields of fresh and dry weight of lettuce in consortium with Peruvian carrot and mineral N (9.88 t ha^{-1} fresh weight and 0.53 t ha^{-1} dry mass). With organic fertilizer under the same conditions (consortium), was obtained 6.68 t ha^{-1} and 0.39 t ha^{-1}, respectively. In this case, it appears that the immediate availability of N, as well as intercropping favored in some way, the target species. Also in lettuce, Steiner et al. (2012) achieved a higher dry matter when applied poultry litter, however, did not differ from pig slurry and chemical treatment with urea. Borges et al. (2013), working with jambu, a plant widely used in northern Brazil, found greater accumulation of biomass in chemical fertilizer in comparison to cattle manure, however, the latter promoted greater phosphorus accumulation in the leaves.

Regarding the size (diameter) of the fruits, without the capsules, there was no significant difference for the

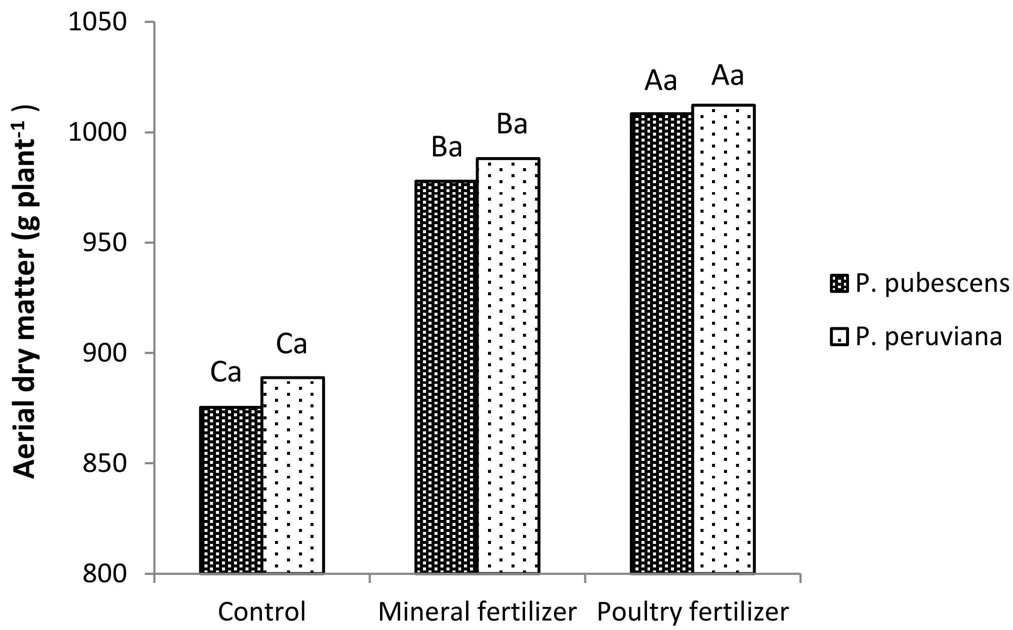

Figure 2. Dry matter of aerial parts (g plant^{-1}) *Physalis*, under different nutritional sources. Uppercase compare the different nutritional and lowercase letters, the two species, by Tukey test (5%).

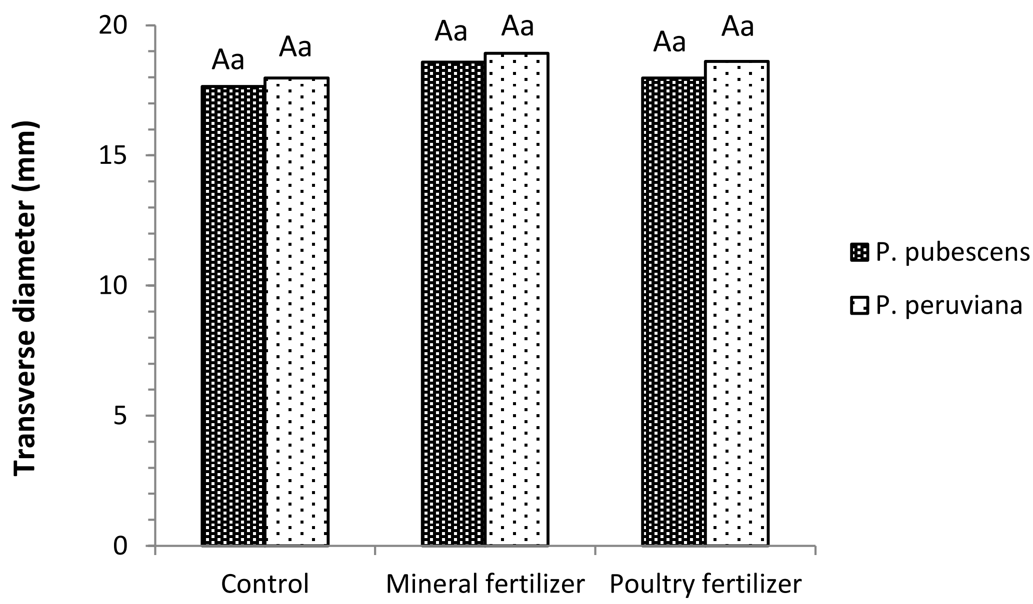

Figure 3. Average fruit diameter (mm) of *Physalis*, under different nutritional sources. Uppercase compare the different nutritional and lowercase letters, the two species, by Tukey test (5%).

different species and for the tested nutritional sources (Figure 3). The average values for both species were 17.81 mm (control), 18.75 mm (chemical fertilizer) and 18.30 mm (organic).

These results differ from those observed by Muniz et al. (2011), that when evaluating the effect of chemical fertilizer (NPK 5:20:10) and organic (manure compost of bovine 50% + 50% swine) in *P. peruviana* obtained larger diameter fruit in plants fertilized with the organic compound (21.14 mm with coat); and the chemical resulted in fruits with a mean diameter of 19.98 mm and 18.99 mm control. Albayrak et al. (2014), analyzing only

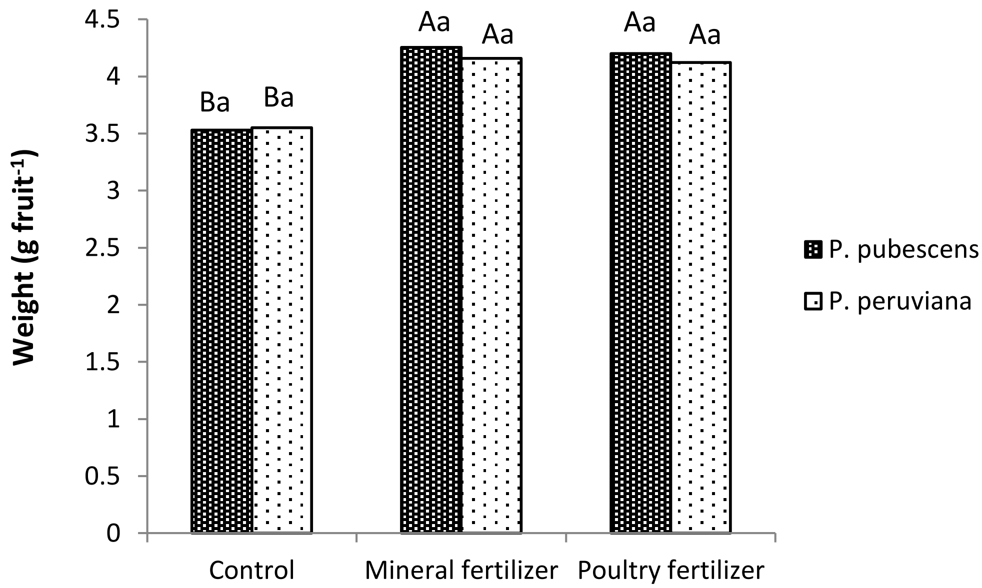

Figure 4. Fruit average mass (g), with capsule, of *Physalis*, under different nutritional sources. Uppercase compare the different nutritional and lowercase letters, the two species, by Tukey test (5%).

the influence of nitrogen, obtained no difference in fruit diameter of *P. peruviana* with increasing doses of this element (from 0.4 to 2 kg ha^{-1}), considering that the control resulted in significantly smaller fruits.

Colombian standards classify the fruits of "uchuva" (*P. peruviana*) in four marketing categories, with relative to the equatorial diameter, with coat: A - 15.0 to 18.0 mm; B - 18.1 to 20.0 mm; C - 20.1 to 22.0 mm; D 22.0 mm (Codex Stan, 2005). Therefore, the fruits of both species of *Physalis* would be within the marketing standards of the largest producer in the Americas. Considering that the fruits were measured without coats, the control with fruit classified at least in category A (17.81 mm), and B or C to the fruits from plants fertilized (18.75 and 18.30 mm, chemistry and organic, respectively). It is clear other factors can contribute to the improvement of the size of the fruit, such as spacing, conduct of the plant, etc. and may result in bigger fruit.

The average masses of fruits (with cap) were enriched with the supply of nutrients, however, there was no significant difference between organic and mineral sources. The organic fertilizer produced fruits averaging 4.2 g, 4.1 g against chemical and 3.5 g for the control (Figure 4).

These results are close to those observed by Muniz et al. (2011) in fruit of *Physalis* derived from plants treated with chemical fertilizer (4.67 g) and organic (4.43 g). Thomé and Osaki (2010) tested different levels of NPK in producing three kinds of *Physalis* (*P. peruviana, P. ixocarpa*, and *P. angulata*) and obtained average fruit mass without significant differences between species, ranging from 1.15 to 1.44 g and only *P. peruviana* and *P. ixocarpa* tended to increase in mass with the increase of fertilizer. In tomatoes produced in the greenhouse, Hernández et al. (2014) did not observe significant differences between mineral and organic fertilizer (manure of sheep + goats and mixing of waste from olive oil industry + manure + pruning of olive).

According to the export standards (Colombia), the *Physalis* fruit should be sold with a minimum weight of 4.0 g (Codex Stan, 2005). Therefore, as seen with the diameter, the fruits produced in the experiment, other than from the control, would be considered acceptable by Colombian standards.

When was analyzed production per plant parameter, there were significant differences in relation to different sources of fertilizer. Both species and the interaction between the factors were not significant. The average fruit yield $plant^{-1}$ was 156.19 g (control), of 274.64 g (chemical fertilizer), and 355.44 g (organic), indicating that both species of *Physalis* showed higher fruit production $plant^{-1}$ when subjected to the latter, with an increase of more than 40% compared with the control (Figure 5).

In this study, although no significant difference between species was found, it was observed that *P. peruviana* excelled when fertilized with poultry litter. In a previous study only with mineral nitrogen fertilization at a dose of 300 kg ha^{-1}, *P. peruviana* produced more fruit, but with smaller individual mass (unpublished data).

In an experiment with three species of *Physalis*, Tomé and Osaki (2010) found that increases in NPK doses did not change the production of fruits per plant, and even between species, there was no significant difference with

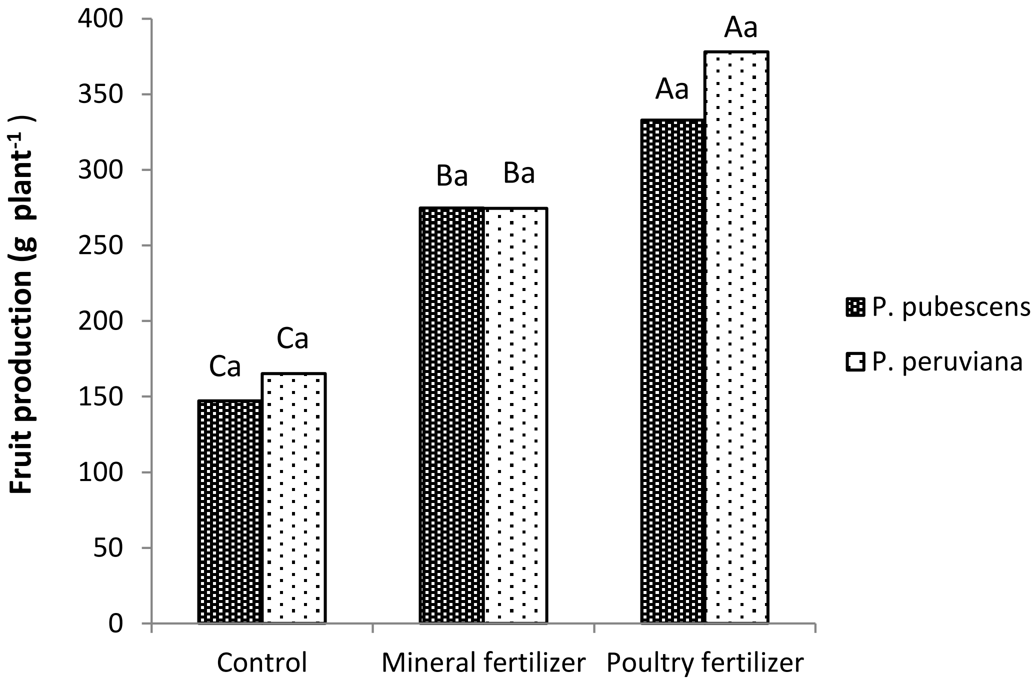

Figure 5. Production (g of fruit plant^{-1}) of *Physalis*, under different nutritional sources. Uppercase compare the different nutritional and lowercase letters, the two species, by Tukey test (5%).

the values being between 1.19 to 1.20 kg of fruit plant^{-1}. Having been set a single harvest, at 140 days after sowing, fruit production in this study was much lower, however, with the continued fruitfulness would be possible to reach higher values, even higher than the authors mentioned above.

Hérnandez et al. (2014), when analyzing the effect of chemical fertilization and two forms of organic compounds (manure of sheep + goats and mixing of waste from for olive oil industry + manure + pruning olive) in tomato production in a greenhouse, they found that the latter were those that produced few fruit by plants - on average 19 and 7.75, respectively, while the control (chemical fertilizer) produced 73.5 fruits per plant. In cucumber, the effect of organic fertilizer of poultry manure base (4 t ha^{-1}) was superior to chemical treatment (NPK), producing more fruit, of better quality and size (Okoli and Nweke, 2015).

With regard to productivity, due to the irregular fruiting, lasting several weeks, approximations were made, taking into account four months of production. The average yields were obtained from 1,041 kg ha^{-1} for the control, 1,831 kg ha^{-1} for chemical fertilizer and 2,370 kg ha^{-1} for organic. Em tomato plants, Muller et al. (2013) found lower productivity of commercial fruits with poultry litter (16.2 t ha^{-1}), reaching 86.9 t ha^{-1} against 100.1 t ha^{-1} with chemical complementation (500: 600: 600 kg ha^{-1} t NPK), in the 2007/2008 harvest, suggesting that the low result of organic fertilizer was due to an imbalance of nutrients or lack of simultaneity between the mineralization of nutrients and plant needs. The same was observed by Hernandez et al. (2014), with tomatoes produced in the greenhouse, with the chemical fertilization overcoming organic in relation to production. Tomato, grown in poor soil (andosol) and imbalance between cations, showed no significant difference in the number of fruits per plant and productivity, for the treatments with chemicals, organic manure (poultry manure) or a combination of both (Tonfack et al., 2008). Araújo et al. (1999) had lower productivity of melon with organic fertilizer when compared to mineral. Since Rech et al. (2006) found that increased doses of organic fertilizer (poultry litter) were able to increase the number of fruit per plant zucchini, but not significantly differ from the mineral fertilizer.

When the gains are estimated with fertilization, through IRPAN, it was found that the organic source, regardless of the species resulted in increased 4.43 kg ha^{-1} of fruits while the chemical was only 2.63 kg ha^{-1}. This demonstrates the potential of organic fertilizer, aviary manure for producing *Physalis*.

In this study, the increase in fruit production observed in plants that received organic fertilizer can be attributed to the availability of nutrients in a balanced way, without loss, either by leaching, fixation or volatilization, as in larger proportions in the mineral nutrient sources. According to Medeiros and Santos (2005), organic fertilizer provides a greater yield by providing sufficient quantities of nitrogen and potassium gradually, supplying, satisfactorily, the plant demand for these elements, which are essential for obtaining adequate production.

Conclusions

Through the results, local conditions, the experimental period, are favorable to the cultivation of the two species, and the organic fertilization, although did not differ in some parameters of chemical, provides higher plants, most mass and fruit in the standards set by international marketing and export standards, thus making possible scale production with utilization of materials (nutrients) that may be available on the property, without waste and with less risk of environmental contamination.

Conflict of Interests

The authors have not declared any conflict of interests.

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