Nitrogen sources on yield, mineral nutrition and bromatology of Cyclanthera pedata

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ABSTRACT

Caygua fruits (Cyclanthera pedata) are used both in cooking and for medicinal purposes. However, few studies on this species, considered a non-conventional vegetable, can be found in literature. This study aimed to assess the responses of caygua crop to green manure and mineral nitrogen fertilization, in relation to marketable fruit productivity, nutrient content in leaves and fruits and bromatological composition. The study was carried out in a randomized block design with four treatments and five replicates: 1) control (without nitrogen); 2) 60 kg ha⁻¹ nitrogen (urea form); 3) green manuring using Cajanus cajans and 4) green manuring using Crotalaria juncea. The plots consisted of three caygua lines with four plants per line (spacing 2x1 m). In the treatments using green manure, three lines of these respective legumes were cultivated. We evaluated marketable fruit productivity, nutrient contents in fruits and leaves and bromatological composition of the fruits. Production of caygua fruits was higher in the treatment consisting of urea application (23.6 t ha⁻¹), followed by Crotalaria juncea (15.6 t ha⁻¹), Cajanus cajans (14.8 t ha⁻¹) and control (9.2 t ha⁻¹). Treatments did not influence the nutrient contents in fruits and leaves and the bromatological composition. However, in relation to higher productivity, the amounts of nutrients absorbed by plants and accumulated in fruits were higher in treatments using mineral fertilization due to the higher yield. The bromatological analysis of fruits showed considerable contents of crude protein and ether extract, highlighting the potential of this species to human diet.

Keywords: Cyclanthera pedata, green manuring, non-conventional vegetable, medicinal plant.

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Caygua (Cyclanthera pedata) is a non-conventional vegetable belonging to Cucurbitaceae family, with indeterminate growth habit, oblong fruits, simple and palmierous leaves and unisexual flowers at the leaf axilla (Macchia et al., 2009). Caygua fruits are dedicated exclusively to human consumption, in food or in the medicine industry production (Costa et al., 2008; Macchia et al., 2009). This species is found growing under spontaneous or sub spontaneous conditions, mainly in Bolivia, Chile, Colômbia, Argentina and Peru (Fernandes et al., 2005). Deep soils with pH close to neutrality are considered suitable for the crop growth. The cycle is approximately 100 days counting from the crop establishment to first harvest, continuing for another 45 to 60 days (Macchia et
Nitrogen sources on yield, mineral nutrition and bromatology of *Cyclanthera pedata*. 

In Brazil, in the Northern Region of Minas Gerais State, caygua plants are especially grown by family farmers, where the fruits are traded in local markets (Fernandes et al., 2005; Costa et al., 2008). According to these authors, production areas are restricted to more fertile soils and their productivities are related, among other factors, to the crop nutritional management. Due to these peculiarities of producers and consumers, no records in statistical yearbooks on the Brazilian production of caygua fruits can be found (Fernandes et al., 2013).

Nitrogen is the most required nutrient by caygua plants, and is one of the most limiting growth factors for this crop. So, developing alternative nutritional management techniques related to nitrogen supply is necessary to produce this vegetable on small-scale farms (Fernandes et al., 2005).

The use of green manures, with nitrogen fixing species, is widely recommended for providing nitrogen-rich plant residues to replace or complement mineral fertilization (Duarte et al., 2013; Zhang et al., 2017; Sarmento et al., 2019). Moreover, this practice contributes to the reduction of greenhouse-gas emissions by agricultural activities (Forte et al., 2017; Fungo et al., 2019).

This study aimed to assess the responses of caygua plants to green manure and mineral fertilizations, in relation to marketable fruit productivity, nutrient content in leaves and fruits and bromatological composition.

**MATERIAL AND METHODS**

The experiment was carried out in the field, from February to October, 2010, at Instituto de Ciências Agrárias of Universidade Federal de Minas Gerais, Montes Claros campus (16°40'51"S, 43°50'22"W, 650 m altitude). The regional climate, according to Köppen, is Aw, tropical savanna, dry winter, with rainfall concentration in summer (Alvares et al., 2013).

The soil in the experimental area is an Oxisol, showing the following characteristics: pH, water = 4.5; P= 1.0 mg dm⁻³; Ca= 2.1 mmolc dm⁻³; Mg= 0.8 mmolc dm⁻³; K= 0.5 mmolc dm⁻³; Al= 23 mmolc dm⁻³; H+Al= 110 mmolc dm⁻³; Zn= 0.3 mg dm⁻³; Mn= 2.2 mg dm⁻³; Fe= 8.3 mg dm⁻³; Cu= 0.1 mg dm⁻³; B= 0.1 mg dm⁻³; organic matter = 18 g kg⁻¹; sand = 500 g kg⁻¹; silt = 80 g kg⁻¹ and clay = 420 g kg⁻¹. The soil analysis was performed following the methods described by Embrapa (1997).

The experimental design was randomized blocks, with four treatments and five replicates. The treatments consisted of: 1) control (without nitrogen); 2) 60 kg ha⁻¹ nitrogen (urea form); 3) intercropped with pigeon-pea (*Cajanus cajan*) cv. *LAPAR 43 Aratã* and 4) intercropped with crotalaria (*Crotalaria juncea*).

The plots consisted of three lines of caygua with four plants per line, conducted in vertical trellis system, spacing 2 m between lines and 1 m between plants. In the treatments using green manure, three lines of these legumes were grown in spacing 0.5 m between lines. In the plots using urea, weeding was done manually between lines. The useful plot consisted of two central plants in the central line.

Three months before implementing the experiment, the soil was plowed and harrowed. Furrows were opened in 30-cm-deep lines and liming was performed using dolomitic limestone, in order to reach 60% of base saturation (Fernandes et al., 2005). The basic fertilization consisted of applying 20 L m⁻³ cattle manure into sowing furrows. Furthermore, 30 days before planting, 30 g m⁻³ of P₂O₅ in the form of reactive phosphate rock, at planting, and 40 g m⁻³ of K₂O were was applied in the form of potassium chloride, splitted in two applications, half at planting and half after 40 days. Analytical determinations of the cattle manure according to the methodology presented by Fermino et al. (2000) presented: C/N= 16.6; total N= 21 g kg⁻¹; P₂O₅ = 9.8 g kg⁻¹; K₂O= 10.6 g kg⁻¹; CaO= 12.8 g kg⁻¹; MgO= 6.5 g kg⁻¹; S= 0.1 g kg⁻¹; B= 38 mg kg⁻¹; Zn= 84 mg kg⁻¹; Fe= 15.3 g kg⁻¹; Mn= 250 mg kg⁻¹; Cu= 36 mg kg⁻¹ dry mass base.

The treatment using mineral fertilization was applied in three monthly applications of 20 kg ha⁻¹ N in urea form, beginning at planting. Green manure was sown continuously, at the same planting date of caygua plants, in furrows, spacing 50 cm from each other, thinning at 10 days after seedling emergence, keeping planting density of 30 plants per linear meter. Both green manures were cut and incorporated into soil when 50% of the plants started flowering, considering that the crotalaria was incorporated at 60 days and pigeon pea at 120 days after sowing.

During the trial period, two manual weedications were performed and complementary irrigation was carried out through drip system.

In order to analyze leaf nutrient contents, two mature leaves were collected from the middle third of each plant, one leaf on each side of the vertical trellis system and fruits were harvested manually when they reached commercial standard, approximately 12 cm long (2 harvests).

Fruits and leaves were oven dried until constant weight at 60°C and they were chemically analyzed considering N, P, K, Ca, Mg, S, B, Zn, Fe and Mn using the methodology proposed by Malavolta et al. (1997).

Samples consisting of 10 fruits per plot were randomly collected and analyzed considering the following bromatological characteristics: moisture, total dry matter, macro and micronutrients, crude protein, ether extract, ash and crude fiber.

All variables were submitted to variance analysis and treatment averages were compared using Tukey test at 5% probability. SAEG statistical software, System for Statistical and Genetics Analyses was used (Ribeiro Júnior, 2001).

**RESULTS AND DISCUSSION**

Productivity of marketable caygua fruits was affected by the treatments (Figure 1), plant yield increased 156.52% with mineral fertilization when compared to the control treatment. Green manures intercropping treatments presented average productivities of marketable fruits 69.57 and 60.87%
greater than the control, respectively for the treatments pigeon pea and crotolaria. These results are corroborated by Fernandes et al. (2005), who reported a high caygua crop N demand, considering N the most extracted nutrient by plants of this species.

In the present study, the maximum production of commercial caygua fruits was 23.6 t ha\textsuperscript{-1}, obtained applying urea (Figure 1). This productivity corresponded to 72.8% of the maximum production obtained by other authors (Fernandes et al., 2013), under similar conditions.

The high capacity of nitrogen supply by green manures is associated with the capacity for biological N\textsubscript{2} fixation resulting from the symbiosis between legumes and bacteria (Brito et al., 2011), as well as their indirect benefits for improving soil chemical, physical and biological properties (Duarte et al., 2013). On the other hand, it is also worth mentioning that the green manures grown intercropped may compete for growth resources with the main crop (Miyazawa et al., 2010; Valadares et al., 2012, 2016). This fact can help to explain the lowest productivity in the treatments which contained green manure compared with the treatment using mineral fertilizer (Figure 1).

In addition, the supply of N mineralized from the green manures biomass mismatched the periods of highest nutritional demand of the caygua plants. (Sharifi et al., 2009) considering that incorporation of crotalaria and pigeon pea was at 60 and 120 days, respectively, after planting.

Our results show that further studies on sowing of green manure in preplanting for this crop are necessary. Guedes et al. (2010) recommend legume planting for obtaining green manure with the necessary advance so that nitrogen mineralization coincides with the nutritional requirements of the main crop.

Future studies should also consider variations in green manure planting density in order to better meet the nutritional requirements of caygua fruits, as well as, other factors that affect N mineralization and the response of crops to these practices, such as soil, climate and plant species (Sharifi et al., 2009; Diniz et al., 2014).

In addition to making nitrogen available, green manures contribute positively to the root system of crops in intercropping or succession (Valadares et al., 2012, 2016). Miyazawa et al. (2010), studying the root systems of legume species intercropped with grasses, observed that both Crotalaria juncea and sorghum showed greater distribution of roots when compared to monoculture, showing complementarity in the exploitation of soil resources.

No significant differences for nutrient contents among treatments, both in fruits and leaves were verified in our study (Table 1). The absence of significant effects on the contents may be associated with the effects of nutrient dilution, since nitrogen is a nutrient that highly affects plant growth (Weih et al., 2011). In the treatment using urea, although the nutrient content in the plant is similar to that of the other treatments, fruit production was 2.58, 1.51 and 1.78 times greater than the control treatments, green manure using pigeon pea and green manure with crotalaria, respectively (Figure 1). Thus, effects of applying N are associated with increases in macro and micronutrients accumulation in caygua fruits (Table 2).

We found no difference among treatments for the bromatological properties of caygua fruits (Table 3).

![Figure 1. Marketable caygua fruit productivity in relation to nitrogen source (variation coefficient 8.6%). Averages followed by same letters did not significantly differ, Tukey's test, 5%. Montes Claros, ICA-UFMG, 2020.](image)

**Table 1.** Nutrient contents in caygua fruits and leaves. Montes Claros, ICA-UFMG, 2020.

| Nutrient | Content in fruits (g kg\textsuperscript{-1}) | Variation coefficient (%) | Content in leaves (g kg\textsuperscript{-1}) | Variation coefficient (%) |
|----------|-------------------------------------------|---------------------------|---------------------------------------------|---------------------------|
| N        | 21.8                                      | 8.5                       | 31.8                                        | 5.6                       |
| P        | 6.0                                       | 9.2                       | 2.8                                         | 4.8                       |
| K        | 38.4                                      | 7.3                       | 25.3                                        | 6.8                       |
| Ca       | 4.2                                       | 5.8                       | 31.4                                        | 6.4                       |
| Mg       | 2.1                                       | 9.4                       | 5.1                                         | 8.2                       |
| S        | 2.0                                       | 13.4                      | 2.3                                         | 12.4                      |
| B        | 10.3                                      | 8.9                       | 26.9                                        | 9.5                       |
| Zn       | 21.3                                      | 5.4                       | 24.8                                        | 7.2                       |
| Fe       | 12.3                                      | 6.8                       | 358.6                                       | 12.6                      |
| Mn       | 5.9                                       | 8.1                       | 33.2                                        | 11.8                      |

(\text{mg kg}\textsuperscript{-1})  
(%)  
(\text{mg kg}\textsuperscript{-1})  
(%)
These results show that even under lower nitrogen availability, such as in the control treatment, the fruits maintained their bromatological properties at the expense of production. On the other hand, considering dry mass production (Figure 1), the amount of protein produced per hectare corresponded to: control (68.61 kg ha⁻¹), pigeon pea (117.37 kg ha⁻¹), crotalaria (99.9 kg ha⁻¹) and urea (163.05 kg ha⁻¹).

Crude protein contents in caygua fruits were similar to the ones found in cucumber fruits (Cucumis anguria) (Lima et al., 2006), which also belongs to Cucurbitaceae family. In addition to the potential benefits to human nutrition, caygua also presents therapeutic properties with anti-inflammatory, hypoglycemic and hypocholesterolemic action (Carbone et al., 2004).

Fruit production was dependent on nitrogen, considering that higher productivities were obtained in the treatment with urea application, followed by pigeon pea and crotalaria green manures.

The treatments did not influence the plant nutrient content in the plant and the fruit bromatological composition. However, the highest amounts of nutrients accumulated in the fruits occurred in treatments with mineral fertilization.

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