Biofertilizers in the coffee crop: application in the leaves and drip in the soil

Biofertilizantes na cultura do café: aplicação nas folhas e gotejamento no solo

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ABSTRACT
Coffee is a commodity important in economic and social terms. In order to obtain high yields and excellent quality products, more studies involving nutrient use efficiency and fertilizer sources need to be developed which offer new management options to producers, potentially providing more sustainable and better agricultural inputs and resources utilization. The aim of the study was to evaluate the application of biofertilizers (OM) in only leaf application and leaf and drip application, in growth, production and fruit quality of coffee cultivated under Savannah conditions (Araguari-MG), compared with conventional chemical coverage fertilization. The experiment was conducted with a randomized block design with three treatments and seven replications. The OM were used in leaf and leaf + drip applications, while the control treatment did not receive any OM application. The OM in leaf and in leaf + drip applications promote higher coffee tree height growth. The OM showed better results than control in 80.3 and 28.4%, in leaf application and leaf + drip application, respectively. However, further investigations need to be developed in order to find out the interference of organic constituents in plant physiology and nutrients dynamics.

Keywords: *Coffea Arabica*. Drip. Organomineral fertilizer.

RESUMO
O café é uma commodity de grande importância em termos econômicos e sociais. No intuito de obter altas produtividades e produtos de excelente qualidade mais estudos envolvendo eficiência no aproveitamento de nutrientes e fontes de fertilizantes precisam ser desenvolvidas, oferecendo respostas aos produtores quanto a manejo mais sustentáveis e melhor aproveitamento de insumos e recursos agrícolas. Neste sentido, objetivou-se avaliar a aplicação de biofertilizantes (OM), somente via foliar e via foliar mais gotejo, no crescimento vegetativo, na produção e na qualidade do café, cultivado em condições de cerrado (Araguari-MG), comparando com a adubação química convencional de cobertura. O delineamento experimental utilizado foi o de blocos casualizados, com três tratamentos e sete repetições. Os OM foram aplicados: via foliar e via foliar + gotejo. O tratamento testemunha não recebeu aplicação de OM. A aplicação de OM via adubação foliar e gotejo promove maior crescimento em altura do cafeeiro. Os OM se sobressaíram à testemunha em 28,4 e 80,3%, em aplicações foliar + gotejo e aplicação foliar, respectivamente. Contudo, maiores investigações precisam ser desenvolvidas no intuito de averiguar a interferência dos constituintes orgânicos na fisiologia e dinâmica vegetal.

Palavras-chave: *Coffea Arabica*. Fertirrigação. Fertilizante organomineral.

1 INTRODUCTION

Coffee is one of the most consumed beverages in the world. In the USA and Brazil, the two largest consumers worldwide, it loses only to water (SILVA et al., 2017, NICOLOPOULOS et al., 2020). This preference is related to the aroma, taste, flavor and the presence of caffeine that improve physical performance and increases energy availability, alertness and concentration (CHENG et al., 2016). In addition, coffee beans are important source of antioxidants and compounds that benefit human health (TRINH et al., 2020).

The crop plays a central economic role in several countries where it is produced and exported.
Brazil is the largest exporter and in 2015 it was responsible for more than a third of the overall world-scale coffee production (ABIC, 2016, TOLEDO et al., 2017).

Coffee quality results from interaction among many different factors including genotype, environmental and management factors (SUNARHARUM et al., 2014, CHENG et al., 2016). Among management issues, plant nutrition stands out (QUINTELA et al., 2011) because the amount of fertilizers applied in coffee is twice the amount needed for the crops of soybean and corn (DOMINGHETTI et al., 2014).

The indiscriminate use of chemical fertilizers has imposed dependence, environment pollution, ecological balance disturbances and effects upon animal health as well. This scenario has encouraged the industries to find alternatives for a more sustainable agriculture (BHARDWAJ et al., 2014, TOMER et al., 2017).

The association of minerals with organic compounds form organominerals (OM), available in the market place in various combinations, with a wide range of products that can fit the needs of each culture and increases the possibilities for farmers. OM also help reduce nutrient losses by increasing the proliferation of microorganisms and therefore the use of fertilizer in the soil, which represents a significant reduction in costs (MOREIRA et al., 2017).

These products have been studied in several crops such as soybeans and corn (BORGES et al., 2015), vegetables such as tomato (COIMBRA et al., 2013) and lettuce (MONTEIRO FILHO et al., 2014) and in perennial plants such as olive (CARVALHO et al., 2015) and coffee (FERNANDES et al., 2007).

The nutrient content of the plants depends on the efficiency of the roots to absorb them and the ability to translocation/utilization of the nutrients by the plants. These aspects will determine the development, quantity and quality of fruit production (AMARAL et al., 2011). Leaf application may be a mechanism to improve nutrient use efficiency through leaf absorption (MANASA et al., 2015). The drip also can be an extraordinary alternative to nutrient use efficiency. Both allow the installment of fertilizers throughout the growing cycle.

Thus, knowledge about new fertilizers and application forms in Brazilian coffee growing can provide valuable information on the management, productivity, as well as agronomic and organoleptic characteristics of coffee (EVANGELISTA et al., 2013).

This informations guides producers to rationalize resource use, increase their incomes by improving the quality of the product and consequently adding value to the product at the commercialization phase. Consumers in developed countries are willing to pay significant premiums for
the certification of sustainability standards (MINTEM et al., 2018).

With the use of methods such as fertirrigation or foliar fertilization, OM products in liquid form can be used. However, because the practice is recent and the information still not clear, especially related to how these products act and influence the production of plants, in the productivity, in the quality of the vegetables and in the dynamics of absorption (SOUZA et al., 2017).

The objective of this study was to evaluate the application of organomineral fertilizers, via drip and leaf, in the growth, production and quality of coffee compared to conventional chemical cover fertilization.

2 MATERIAL AND METHODS

The experiment was conducted in the Amanhece district, municipality of Araguari- MG, situated at 18°38'56" south latitude and 48°11'13" longitude west and altitude average 1013 m above sea level. It presents tropical climate of altitude Cwa according to a classification of Köppen. The soil is classified as Red Latosol (EMBRAPA, 1999).

The study was performed with a coffee crop of the Topázio cultivar, eight years old, spaced on 3.80 m between rows and 0.70 m between plants. Soil chemical analysis performed before treatment application at 0-20 cm depth showed the following results: P = 8.72 mg dm\(^{-3}\); K = 70 mg dm\(^{-3}\), pH = 5.3; Ca\(^{2+}\) = 1.50 cmol\(_c\) dm\(^{-3}\); Mg\(^{2+}\) = 0.20 cmol\(_c\) dm\(^{-3}\); Al\(^{3+}\) = 0.1 cmol\(_c\) dm\(^{-3}\); T: 7.6 cmol\(_c\) dm\(^{-3}\) e SB = 1.88 cmol\(_c\) dm\(^{-3}\).

The experimental design was a randomized block design with three treatments and seven replications. Each plot was composed of 42 rows, the useful area being the seven central rows. The treatments used were: control (without OM fertilizers application), leaf fertilization and leaf fertilization associated with drip irrigation. The rates of OM used are shown in Table 1.

| DAH   | TOC\(^1\) | N\(^2\) | K\(^3\) | Ca\(^4\) | S\(^5\) | Zn\(^6\) | Mo\(^7\) | Cu\(^8\) | B\(^9\) | Mn\(^{10}\) |
|-------|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 0     | 103.5    | 115    | 11.5   | 5.75   |        |        |        |        |        | 17.25   |
| 15 and 45 | 126.5   | 126.5  | --     | 273.5  | 150.8  | 130    | 2.6    | 13     | 66.7   | 130    |
| 90    | 51.75    | 5.75   | 5.75   | 203    | 150.8  | 288    | 2.6    | 13     | 61     | 8.63   |
| 140   | 78       | --     | 780    | --     | --     | --     | --     | --     | --     | --     |

*Table 1 - Composition of liquid organomineral used in leaf application at days after harvest (DAH)*

\(^1\)Total Organic Carbon; \(^2\)Nitrogen; \(^3\)Potassium; \(^4\)Calcium; \(^5\)Sulfur; \(^6\)Zinc; \(^7\)Molybdenum; \(^8\)Copper; \(^9\)Boron; \(^{10}\)Manganese
In the treatment leaf fertilization associated with drip irrigation, in addition to the nutrients mentioned in the Table 1 were applied weekly 540; 310.5; 241.5 and 23 g ha\(^{-1}\) of Total Organic Matter; Total Organic Carbon; Nitrogen and Potassium, respectively.

For the analysis of the macro and micronutrient contents of the plants, twenty leaves of ten plants of each plot were obtained randomly in productive branches of the third and fourth pairs, located in the middle height of the plant on two sides of the coffee line, according to methodology EMBRAPA (1999). The leaf samples were stored in paper bags, identified and transported to the laboratory for analysis.

Spraying was performed with a 20 L sprayer with working pressure of 4 Kgf, and a drip irrigation application was performed with the aid of a fertilizer injector Venturi type. Phytosanitary control was made with insecticides and fungicides recommended for coffee, when required.

The plants’ vegetative growth, the height and the diameter of the skirt of the coffee tree were measured with tape measure. The mean diameter of the skirt was obtained with the two-way reading of the plant, line and street, in the larger diameter portion, at the end of the harvest, obtaining the average of the two readings for analysis purposes.

The coffee beans were harvested manually, in ten randomized plants per plot, when the percentage of green beans was less than 5%. After the collection, the grains were placed in a cement yard for the coffee bean drying process. After reaching a value close to 12% moisture, the grains were peeled and weighed in an analytical balance.

For the estimation of liters of coffee per plant, the weight has been transformed into sixty kilogram bags, using the harvest income factor (ratio of the amount of grains harvested to the amount of grains after processing).

The results were submitted for variance analysis and means were compared by the Tukey test using the software SISVAR (FERREIRA, 2011).

### 3 RESULTS AND DISCUSSION

Leaf associated with drip fertilization stimulated coffee height development and was 38% higher than control. The skirt diameter did not present significant differences between the OM fertilizers applications (Table 2).

Nutrients and other components that stimulate plant development enter through the flow of water available to the plant. Therefore, the supply of the dissolved mineral elements in the irrigation water is interesting because they are readily available for absorption, which allows the translocation and action
at the specific points of the plant metabolism and explains the better results related to the drip.

Table 2 - Coffee height and diameter of cv. Topazio according to OM fertilizers applications

| Treatments                  | Height (cm) | Diameter (cm) |
|-----------------------------|-------------|---------------|
| Leaf application            | 24.57 b     | 17.28 a       |
| Leaf and drip application   | 40.42 a     | 23.14 a       |
| Control                     | 29.14 b     | 11.85 a       |
| CV (%)                      | 16.93       | 19.93         |

¹Means followed by the same letter do not differ statistically by the Tukey test at 5% probability

Fertilization associated with irrigation as observed in the present study improved coffee growth. Several studies corroborate the data presented (COSTA et al., 2010, REZENDE et al., 2010, ASSIS et al., 2015). Magiero et al. (2017) reported even reductions in the fertilization standard rate.

Fertilizer addition to the soil temporarily change the availability and leaching of nutrients, according to the solution dynamics, by the chemical balance between the solid and liquid phases (TEIXEIRA et al., 2014). This fact reflects on what will be absorbed by the roots of the plants. According to this study, it was observed that the application form interferes in the absorption efficiency, which reflects in the plants’ growth.

Gomes (2007), in a study with the cultivar Rubi, during five years, observed greater vegetative growth when the coffee was drip compared to another treatment without drip. Therefore, the nutrients application associated with irrigation brings satisfactory results to the coffee (SCALCO et al., 2014) and shoot growth (AQUINO et al., 2012), including, as observed in this experiment, with incorporation of OM in the system.

Arantes et al. (2006) did not observe differences between drip levels in coffee vegetative growth. However, the plant height, the number of internodes, and the canopy diameter were linearly increased with increasing irrigation depths. This emphasizes the essentiality of water in plant metabolism and development.

Fagundes (2006) also verified that liquid fertilizers added to the crop lead to positive responses in coffee vegetative development. For Resende et al. (2010), drip is a good alternative to be used in the formation of coffee plants since they have advantages over conventional fertilization. In the present work, the association between liquid OM applications and the drip process was a potential alternative for coffee
management.

The macro and micronutrients: N, P, Ca, S, B, Cu, Fe, Zn showed no significant differences between the treatments (Table 3).

The potassium (K) content presented a significant difference in relation to the control. The leaf fertilization and leaf associated with drip showed no significant differences between them, with K levels of 30 g kg\(^{-1}\) and 29 g kg\(^{-1}\), respectively (Table 3). The K content was significant possibly because of its ease in being absorbed through the leaf. Folegatti (1999) stated that the use of this nutrient could reach 90% when applied in liquid form, an interesting result, since, according to Silva et al. (2001), the application of K responds in coffee production.

For the Magnesium (Mg), the control showed a significant difference in relation to the other treatments, with 3.0 g kg\(^{-1}\) (Table 3). Probably the result can be related to the ratio of K/Mg and Mg/Ca. According to Laviola et al. (2007), the concentrations of these nutrients in leaves and grains are influenced not only by the fertilization levels, but also by factors that determine the rate of mineral distribution in coffee plants, such as the pending grain load.

The Manganese (Mn) provided a content of 109.50 mg kg\(^{-1}\) in the coffee leaves and it was significant for the leaf associated with drip (Table 3). According to Freitas et al. (2007) the plant response to nutrients is also influenced by the fertilization season. The leaf fertilization is convenient to maximize productivity, if applied many times during the crop cycle. A staggered supply of nutrients minimizes losses of natural resources and optimizes nutrients uptake (DOMINGHETTI et al., 2014), which leads to improvements in the management and ecosystem sustainability.

Table 3 - Macronutrients and micronutrients in leaves of coffee cv. Topázio according to OM fertilizers applications

| Treatments | N (g kg\(^{-1}\)) | P (mg kg\(^{-1}\)) | Ca | Mg | S | B | Cu | Fe | Mn | Zn | CV |
|------------|----------------|------------------|----|----|---|----|----|----|----|----|----|
| Control    | 27.8 a 0.0 a 0.0 a 0.0 a 0.0 a | 9.4 a 23.5 a 00.0 a 3.9 a |
| Leaf and drip application | 8.5 a 0.9 a 0.0 a 0.0 a 0.0 a | 34.9 a 8.0 a 81.0 a 09.5 a 5.1 a |
| Leaf fertilization | 8.2 a 0.9 a 0.0 a 0.0 a 0.0 a | 34.7 a 9.5 a 23.5 a 00.0 a 3.9 a |
| Control (%) | 97.7 97.7 96.9 97.6 97.9 | 97.6 79.6 98.1 4.1 |

1Means followed by the same letter do not differ statistically by the Tukey test at 5% probability.

The same was observed by Fernandes (2007) evaluating the cultivar Catuaí Vermelho IAC 144, in
an analysis of the mineral and organomineral fertilizers efficiency on vegetative growth and coffee production, cultivated under Savannah conditions. The researcher also did not observe any difference between macro and micronutrient contents.

The nutrient leaf content of coffee plants depends on root absorption, which is influenced by external and internal factors (ARAUJO et al., 2007). Organic compounds in organominerals, for example, may aid in cation availability, such as K\(^+\), Ca\(^{2+}\) and Mg\(^{2+}\). Thus, they may interfere with nutrient concentration and competitive effects at the absorption sites.

The leaf OM fertilizers applications reflect a higher coffee roasted and productivity, compared with control (Table 4). For productivity, the OM showed better results than control in 80.3 and 28.4 % in leaf application and leaf + drip application, respectively.

Table 4 - Roasted coffee, yield (liters of coconut coffee per bag of 60 kg) and average productivity (sacks benefited per hectare) of coffee cv. Topazio according to OM fertilizers application

| Treatments                      | Coffee roasted (kg ha\(^{-1}\)) \(^1\) | Productivity (sc ha\(^{-1}\)) \(^1\) |
|--------------------------------|--------------------------------------|--------------------------------------|
| Leaf application               | 4092.86 a                            | 33.25 a                              |
| Leaf and drip application      | 2952.86 ab                           | 23.67 ab                             |
| Control                        | 2430.00 b                            | 18.44 b                              |
| CV (%)                         | 15.38                                | 16.80                                |

\(^1\)Means followed by the same letter do not differ statistically by the Tukey test at 5% probability

Oliveira et al. (2010) observed a distinct response of the present study in the city of Lavras (MG), where drip in the coffee crop was economically feasible due to the increase in productivity (33.48%). The authors drew attention to the fact that the costs are not related to the implementation of the irrigation system, but to variable costs such as labor and energy.

The dynamics between the constituents of the products change with the metabolism of the plants. It is important to understand that the effects of the organic components are revealed in the long term because their performance in the soils is gradual. Therefore, they are hardly reflected in initial evaluations (FERNANDES et al., 2013, MAZEIKA et al., 2016). According to Fernandes (2007), it is possible to notice any evident income difference only after some years of cultivation.

The organic matter of organic and OM fertilizers can increase fertility, improve soil biological quality and physical characteristics, and promote beneficial effects on soil aggregation, porosity, retention and infiltration (RODRIGUES et al., 2013).

It has been observed that the form of application can determine plant assimilation due to the
dynamic interaction between the ecosystem factors. Finally, more studies on the application of organominerals in drip are necessary since it favored vegetative development but left also an open question as to the effectiveness in the productivity.

4 CONCLUSIONS

The OM in leaf application and in leaf + drip promotes higher coffee tree height growth.

The OM showed better results than control in 80.3 and 28.4%, in leaf application and leaf + drip application, respectively.

Further investigations need to be developed in order to find out the interference of organic constituents in plant physiology and nutrients dynamics.

5 DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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