EVALUATION OF SLOW RELEASE FERTILIZER ON THE INITIAL DEVELOPMENT AND COFFEE PRODUCTION

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ABSTRACT: The objective in this work was to evaluate the efficiency of slow release fertilizer in seedling production, initial development and first coffee production. The research was carried out at Sítio Santa Felicidade, Campestre - MG, Brazil, in a randomized block design with two treatments and ten replicates, totaling 20 experimental plots. Coffee seedlings were produced using Ciclus Substrate (20% N, 22% P₂O₅ and 5% K₂O) and conventional fertilizers 4 kg simple super phosphate (18% P₂O₅) and 0.25 kg Potassium Chloride (58% K₂O). The variables evaluated were size, dry and fresh matter of the shoot and root system, and the seedlings were transplanted to the field and those from Ciclus Substrate received in the first year Ciclus NS (30% N) and in the second year: NK (19-00-19) and conventionally produced with conventional fertilizers (20-00-20 and 25-00-25 respectively), the variables evaluated were: shoot growth, length and number of plagiotropic branch internodes Slow release fertilizer ciclus Substrate has been found to be a viable technology for the production of arabica coffee seedlings, coffee planting NS provides good plant development and coffee producing NK provides good plant growth and higher productivity.

Index terms: Coffea arabica L., Ciclus, Productivity.

1 INTRODUCTION

More sustainable production systems in coffee growing have aroused the interest of researchers, seeking responsible and more efficient mechanisms in plant nutrition. Studies and tools that describe the sustainable development practices of coffee growing, nutrient effectiveness in relation to productivity increases with economic return are essential. Nutritional imbalance has a direct impact on crop yields, being one of the major contributors to production declines (Silva & Lima, 2012).

Brazilian soils have the characteristic of high acidity and low fertility (Franco Junior, 2017), being dependent on high doses of fertilizers, directly impacting the final value of the harvested product, making a good soil sampling to be the basis for Proper planning of the use of correctives and fertilizers and, combined with proper management practices, enable high productivity to be achieved (Guarçoni et al., 2017). However, due to the high cost of fertilizers and the low natural fertility in Brazilian soils, the development of techniques to increase the effectiveness of the fertilizers to be used is increasingly urgent.

Due to the agricultural areas advancement, especially in the cerrado and the need for productivity gains, the fertilizers availability in the market has become a concern for the production system, since 70% these fertilizers are imported (Brandão; Penedo; Bastian Pinto, 2013). This scenario also applies to coffee growing, which has expanded into the cerrado, Western Bahia, Northern Minas Gerais. It is worth mentioning that in traditional coffee growing regions, two actions have marked the activity, the opening of new cultivation areas, when possible, and the renewal coffee crops.

Thus, sustainable practices that improve fertility, such as replacing mineral nitrogen with other practices, without affecting productivity and production cost should be adopted.

Fertilizers and correctives are estimated to account for 30% of the coffee production cost, and in Brazil nitrogenous fertilizers consume approximately 3.5 million tons annually (Rodrigues et al., 2015). Thus sustainable practices that improve fertility, such as replacing mineral nitrogen with other practices, without affecting productivity and production cost should be adopted. Productivity of perennial species has its growth rate affected by nutritional restrictions, high acidity, and an adequate nutritional diagnosis "soil sampling" is essential for successful implantation (Natale et al., 2012). The nutritional demand of plants is directly related to the contents of the plant material and the total dry matter produced (Castoldi et al., 2009).
Plant nutritional imbalance promotes abnormalities, characteristics of each nutrient in deficiency or excess. The symptomatology results from the fact that each element exerts in the metabolic function, whatever the plant, being able to express in leaves, stems and roots, thus indicating the nutritional state of the vegetable.

The traditional coffee seedling production and marketing system is composed of polyethylene bags with substrates (Nasser et al., 2009). Generally these substrates are composed of soil, organic material (manure or organic compost) and mineral fertilizers. The new technology in seedling production is the use of slow release and controlled fertilizers, which are soluble and grouped in granules coated with organic or even elastic resin. In order to minimize problems with burning the roots by over fertilization and promote slow release, which is of utmost importance. Thus the nutrient release is continuous and according to the temperature and humidity of the soil (Simão, 2017).

Slow release fertilizers in their various forms are very useful for producing seedlings in containers. The main idea of slow release fertilizers is the continuous release of nutrients, keeping the plant continuously nourished in its growing period. The advantages of using it are numerous, among them the reduction of labor and less nitrogen loss through volatilization (Sharma, 1979; Simão, 2017).

Nutrients in slow release fertilizers include soluble compounds inside them (NPK and some micronutrients), surrounded by a semipermeable membrane which, due to temperature, has an elastic characteristic and, therefore, the ability to dilate and contract, controlling the gradual release and osmotic nutrients to the substrate (Santos et al., 2018), maintaining constant levels of the essential elements for seedlings throughout the growing period (Jose; Davide; Oliveira, 2005; Rossa et al., 2015).

To obtain quality seedlings, the morphological parameters must be observed. According to Dardengo et al. 2013, the main parameters that determine seedling quality are height, neck diameter, shoot and root weight, and the correlation between these parameters with the height and neck diameter ratio.

Coffee, just like any species, needs various nutrients for its complete development. Coffee growers already have technical bulletins with recommendations for coffee nutrition at all stages of their cycle (planting, first and second year of formation and crops in production (Vilela et al., 2017).

Growth can be defined as net accumulation of carbon and other organic components in plants, and carbon gain is determined by local availability of light, water and nutrients (Buchanan; Gruissen; Jones, 2000). In practice, for measuring growth, the dry matter produced over a period of time can be evaluated by the absolute growth rate and the relative growth rate. The first index represents the dry matter produced per unit area or plant over a period of time and the second index represents the dynamics of dry matter accumulation over time, related to its initial dry matter (Hunt et al., 2002). Thus, the relative growth rate represents the accumulation of dry matter per unit of dry matter and per unit of time.

Genetic and edaphoclimatic factors directly influence coffee growth. Research has been conducted and evidenced that *Coffea arabica* has its own species-specific characteristics (Fonseca, et al., 2006).

The objective in this work was to evaluate the efficiency of slow release fertilizer in seedling production, initial development and first coffee production.

### 2 MATERIAL AND METHODS

The experiment was carried out from May 2016 to May 2019 at Sitio Santa Felicidade, Campestre - Southern MG, located at the geographic coordinates: 21°43’12” South and 46°14’45” West, at an altitude of 1.112 meters and with hot and temperate climate. The summer with higher rainfall than winter is classified as Cwb according to Köppen (1936) and Geiger (1954). The average annual temperature is 18.9 °C and the average rainfall is 1609 mm according to the Clima-Date.Org website.

The research was carried out in two stages, the first, the evaluation of seedlings and the second, evaluation of the development and production of adult plants.

The experiment was carried out in a randomized block design (DBC) with two treatments (slow release and conventional fertilizer) and ten replicates, totaling twenty experimental units. Each plot consisted of 50 seedlings.

The *Arabica* coffee (*Coffea arabica*) cultivar used was Topaz. For the production of the seedlings 11 x 22 cm bags were used, containing...
subtract composed of soil and tanned manure, in
the proportions of 3:1 and the treatment using was
1.4 kg of Ciclus Substrate (20% N, 22% P₂O₅ and
5% K₂O) and conventional fertilizers with 2.0 kg
simple super phosphate (18% P₂O₅) and 0.25 kg
potassium chloride (58% K₂O).

When the seedlings had 4 definite pairs of
leaves, the following parameters were evaluated:
shoot height, root system length, fresh and dry
weight of shoot and root system. Height and
length evaluations were performed with the aid of
a graduated ruler. The seedlings were dried in a
greenhouse with forced air circulation at 65 °C,
using six seedlings for each plot.

Secondly, after the seedling evaluation,
twenty remaining seedlings of each plot were
transplanted in the field (definitive planting), with
a spacing of 3.5 x 0.5 m. The seedlings that were
produced with Ciclus Substrate used the treatment
with ciclus NS at a dosage of 20 g per pit and
the seedlings that were conventionally produced
received four 10 g of 20-00-20 per pit, in addition
to eight liters of tanned manure per plant in all
treatments.

After the first year of planting, the six
central plants of each plot were evaluated: shoot
growth at plant height, plagiotropic branch length
and number of plagiotropic internodes evaluated.

In the second year, 100 g of Cyclus NK (19-00-19) was applied to plants from ciclus Substrate
seedlings and to the conventional three fertilizers
with 50 g of 25-00-25 per plant.

In the same six central plants, plant growth
in height, plagiotropic branch length at 50 cm
from ground level, number of internodes and yield
were evaluated.

For the first production, the same six central
plants were evaluated and the measurement
performed in liters per plant and converted by
productivity, considering 500 liters.bag⁻¹.

Data were statistically interpreted by
analysis of variance. The means were grouped
by Scott-Knott test at 5% probability, using the
statistical software SISVAR® (Ferreira, 2014).

3 RESULTS AND DISCUSSION

In evaluating coffee seedlings
development, it was possible to observe that, for
the shoot height there was no statistical difference
between the treatments used (Table 1). Regarding
the root system length, the slow release fertilizer
Ciclus Substrate was more efficient, providing
higher growth when compared to the conventional
one (Table 1). Similar effect was observed when
evaluating the seedlings total length, in which the
use of slow release fertilizer also promoted better
development, confirming the study by Bachão et
al. (2018).

Oliveira et al. (2018) and Santos et al.
(2018), in their research, also obtained results
in which the seedlings production using slow
release fertilizers resulted in better root system
development.

The variance analysis showed statistical
difference between treatments regarding fresh
matter of coffee seedlings. It turns out that, greatest
fresh matter was produced by the root system
when using the Ciclus Substrate (Table 2). This
result influences in the total fresh matter, with a
difference 0.54 g in relation to the conventional
one.

Regarding the seedlings dry weight, there
was no statistical difference between treatments
(Table 3), contrary to data from Oliveira et al.
(2018), in which the dry matter of the root system
coffee seedlings produced with Ciclus was
higher than that produced using conventional
fertilizers.

According to Sgarbi et al. (1999) and França
et al. (2009) the application of Osmocote®
(19-06-10) to the Eucalyptus urophylla
clonale provided higher growth and higher dry weight root using
slow release fertilizers to the substrate compared
to conventional fertilization.

Analyzing the results obtained after the first
year of transplantation (Table 4), it was possible
to observe that the plants which came from the
seedlings produced with slow release fertilizers
and received application of the same technology,
presented a higher height, differing statistically
from the plants of conventional fertilizers.
However, when analyzing plagiotropic branch
length and number of internodes, no statistical
differences were observed (Table 4).

After the second year of transplantation,
the average tests show that plants from controlled
release fertilizer seedlings managed in the first and
second year resulted in higher plants with longer
plagiotropic branch length and higher number of
internodes (Table 5). Pinto et al. (2011), reports
that Ciclus promoted increase in plagiotropic
branch length and number of internodes compared
to conventional fertilizer.

The first coffee production demonstrated
superior productivity in Ciclus managed plants,
resulting in a differential 3.2 more coffee bags
when compared to the conventional one (Table 6).
Pinto et al. (2011) and Pinto, Barbosa e Santana
(2012), report that Ciclus promoted productivity
increase in coffee crop.
### TABLE 1- Coffee seedlings development (cm).

| Treatments    | Shoot height | Root system length | Total length |
|---------------|--------------|--------------------|--------------|
| Ciclus Substrate | 23.7 A       | 20.4 A             | 44.10 A      |
| Conventional  | 21.9 A       | 18.7 B             | 40.60 B      |

*Averages followed by the same letter belong to the same cluster by the Scott-Knott test at 5% probability.

### TABLE 2- Fresh matter (grams) of coffee seedlings.

| Treatments  | Shoot fresh matter | Root fresh matter | Total fresh matter |
|-------------|--------------------|-------------------|--------------------|
| Ciclus Substrate | 7.44 A           | 3.82 A            | 11.26 A           |
| Conventional | 7.17 A            | 3.55 B            | 10.72 B           |

*Averages followed by the same letter belong to the same cluster by the Scott-Knott test at 5% probability.

### TABLE 3 - Dry weight (grams) of coffee seedlings.

| Treatments    | Dry weight shoot | Dry weight root | Total dry weight |
|---------------|------------------|-----------------|------------------|
| Ciclus Substrate | 1.83 A           | 0.55 A          | 2.38 A           |
| Conventional  | 1.78 A           | 0.48 A          | 2.26 A           |

*Averages followed by the same letter belong to the same cluster by the Scott-Knott test at 5% probability.

### TABLE 4 - Plant height, length and number of internodes in plagiotropic branches in the first year.

| Treatments | Height (cm) | Plagiotropic length (cm) | Number of internodes in plagiotropic |
|------------|-------------|----------------------------|-------------------------------------|
| Ciclus NS  | 62.2 A      | 48.4 A                     | 8.2 A                               |
| Conventional | 55.7 B     | 42.5 A                     | 7.9 A                               |

*Averages followed by the same letter belong to the same cluster by the Scott-Knott test at 5% probability.

### TABLE 5 - Plant height, length and number of internodes in the plagiotropic branches in the second year.

| Treatments | Height (cm) | Length plagiotropic at 50 cm from the ground (cm) | Number of internodes in plagiotropic |
|------------|-------------|---------------------------------------------------|-------------------------------------|
| Ciclus NK  | 119 A       | 76.3 A                                            | 17.8 A                              |
| Conventional | 105 B     | 69.2 B                                            | 15.2 B                              |

*Averages followed by the same letter belong to the same cluster by the Scott-Knott test at 5% probability.

### TABLE 6 - Productivity at first crop (bags ha⁻¹)

| Treatments | Productivity |
|------------|--------------|
| Ciclus     | 28.32 A      |
| Conventional | 25.08 B   |

*Averages followed by the same letter belong to the same cluster by the Scott-Knott test at 5% probability.
4 CONCLUSIONS

It is concluded that, slow release fertilizer Ciclus Substrate has been found to be a viable technology for the production of quality arabica coffee seedlings, Ciclus NS for coffee planting provides good plant development and NK as fertilizer for coffee producing provides good plant growth and higher productivity.

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6 REFERENCES

BACHIÃO, P.O.B; MACIEL, A.L.R, AVILA, R.G CAMPOS, C.N. Crescimento de mudas de café em tubetes com fertilizante de liberação lenta, Revista Agrogeoambiental, Pouso Alegre, v.10, n.1, p.105-116, mar. 2018. DOI: http://dx.doi.org/10.18406/2316-1817v10n12

BUCHANAN, B.B.; GRUISSEN, W.; JONES, R.L. (eds.). 2000. Biochemistry and molecular biology of plants. American Society of Plant Physiologists, Rockville

BRANDÃO, L.E.T; PENEDO, G.M.; BASTIAN-PINTO, C. The value of switching inputs in a biodiesel production plant. The European Journal of Finance, vol. 19(7-8), pages 674-688, September. 2013.

CASTOLDI, R.; CHARLO, H.C.O.; VARGAS, P.F.; BRAZ, L.T. Crescimento, acúmulo de nutrientes e produtividade da cultura da couve-flor. Horticultura Brasileira, v.27, n.1, p. 438-446. 2009.

DARDENGO, M.L.J.D; SOUZA E.F.; REIS, E.F.; GRAVINA, G.A. Crescimento e qualidade de mudas de café conilon produzidas em diferentes níveis de sombreamento, Coffee Science, Lavras, v. 8, n. 4, p. 500-509 out./dez. 2013.

FERREIRA, D.F. Sisvar: um guia dos seus procedimentos de comparações múltiplas Bootstrap. A Ciência e agrotecnologia. [online]. v.38, n.2, pp.109-112. 2014.

FONSECA, A.F.A.; SEDIYAMA, T.; CRUZ, C.D.; SAKAIYAMA, N.S.; FERRÃO, M.A.G.; FERRÃO, R.G.; BRAGANÇA, S.M. Divergência genética em café Conilon. Pesquisa Agropecuária Brasileira, v. 41, n. 6, p. 599-605, 2006

FRANÇA, L.V.; DUBOC, E.; JUNQUEIRA, N.T.V. Efeito de diferentes doses de fertilizante de liberação controlada em mudas de pequi (Caryocar brasiliense Camb.). EMBRAPA (Separatas): v.1, p.1-7. 2009.

FRANCO JUNIOR, K. S. Uso de bioativador de solo associado a diferentes coberturas vegetais e a influência nas características químicas, físicas e microbiológicas. 2017. 82 f. Dissertação (Programa de Mestrado em Sistemas de Produção na Agropecuária) - Universidade José do Rosário Vellano, Alfenas.

GEIGER, R. KASSIFIKATION DER KLIMATE NACH IN LANDOLTBÖRNSTEIN ZAHLENWERTE UND FUNKTIONEN AUS PHYSIK, CHEMIE, ASTRONOMIE, GEOPHYSIK UND TECHNIK, VOL. 3, KÖPPEN W (ED). Springer: Berlin, 603–607. 1954.

GUARÇONI, A.; ALVAREZ, V.; VÍCTOR HUGO; SOBREIRA, F. M. Fundamentação teórica dos sistemas de amostragem de solo de acordo com a variabilidade de características químicas. Terra Latinoam, Chapingo, v. 35, n. 4, p. 343-352, Dec. 2017.

HUNT, R.; CAUSTON, D.R.; SHIPLEY, B.; ASKEW, P. A modern tool for classical plant growth analysis. Annals of Botany, v.90, p.485-488. 2002.

JOSE, A.C.; DAVIDE, A.C.; OLIVEIRA, S.L. Produção de mudas de areoeira (Schinus terebinthifolia Raddi) para recuperação de áreas degradadas pela mineração de bauxita. Cerne, vol.11, n.2, p.187-203, 2005.

KÖPPEN, W.P. DAS GEOGRAPHISCHE SYSTEM DER KLIMATE. Gebrüder Borntraeger: Berlin. 1936.

NASSER, M.D.; LIMA JUNIOR, S.; GALLO, P.B.; SOUZA, P.S.; BREDAJÚNIOR, J.M. Desenvolvimento e qualidade de mudas de café (Coffea arábica L.) produzidas em sacola plástica convencional, tubete e sacola de tnt. In: Simpósio de Pesquisa dos Cafés do Brasil (6.: 2009: Vitória, ES). Anais Brasilia, DF: EMBRAPA – Café, 2011.
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NATALE, W.; ROZANE, D.E.; PARENT, L.E.; PARENT, S.E. Acidez do solo e calagem em pomares de frutíferas torpical. Revista Brasileira de Furticultura, v.34, n.4, p. 1294-1306, Dezembro. 2012.

OLIVEIRA, P.C.; FRANCO JUNIOR, K.S.; BRIGANTE, G.P.; SILVA, T.M. Efeito do adubo de liberação lenta no crescimento e desenvolvimento do sistema radicular de mudas de café arábica. Revista Cerrado Agrociências, n.9, p. 105 - 110, nov. 2018.

PINTO, M.F.; REZENDE, M.C.; SANTANA, M.R.; GOMES, M.T.B.; LEITE, J.F.A. Resultados Parciais do produto ciclus NK, nitrogenio de liberação lenta, aplicados a lavoura em produção. 37.º Congresso Brasileiro de Pesquisas Cafceiras, Araxá MG, 2011. Disponível em http://www.sapc.embrapa.br/arquivos/consorcio/spcb_anais/simposio7/42.pdf

PINTO, M.F.; BARBOSA, C.M.; SANTANA, M.R. Comportamento do adubo de liberação lenta Ciclus NK, uma única aplicação, na cafecicultura da Zona da Mata, 38º Congresso Brasileiro de Pesquisas Cafceiras, Caxambu MG, 2012.

RODRIGUES, R.B.; OZORIO, L.M.; PINTO, C.L.B; BRANDÃO, L.E.T. Opção de troca de produto na indústria de fertilizantes. Revista Administração, São Paulo, v.50, n.2, p.129-140, abr./maio/jun. 2015

ROSSA, U.B.; ANGELO, A.C.; WESTPHALEN, D.J.; OLIVEIRA, F.E.M.; SILVA, F.F.; ARAUJO, J.C. Fertilizante de liberação lenta no desenvolvimento de mudas de Anadenanthera peregrina (L.) Speg. (ANGICO-VERMELHO) E Schinus terebinthifolius Raddi (AROEIRA-VERMELHA). Ciência Florestal, 25(4), 841-852. 2015

SERRANO, L.A.L.; SILVA, C.M.M; OGLIARU, J; CARVALHO, A. J.C.; MARINHO, C. S.; DETMANN, E. Utilização de substrato composto por resíduos da agroindústria canavieira para produção de mudas de maracujazeiro-amarelo. Revista Brasileira de Fruticultura, Jaboticabal, v.28, n.3, p.487-491, 2006.

SHARMA, G. C. Controlled-release fertilizers and horticultural applications. Scientia Horticulturae, Alabama, USA, v.11(2): 107-129. 1979.

SILVA, S.A.; LIMA, J.S.S. Avaliação da variabilidade do estado nutricional e produtividade de café por meio da análise de componentes principais e geoestatística. Revista Ceres, Viçosa, v.59, n.2, p. 271-277, Mar./ Apr. 2012.

SIMÃO, L.A. Fertilizante de liberação controlada no crescimento e desenvolvimento de plantas de mamoeiro a campo. Dissertação (Mestrado em Agricultura Tropical). Universidade Federal do Espírito Santo. São Mateus, ES: UFES, 42f. 2017.

VILELA, D.J.M.; CARVALHO, G.R.; BOTELHO, C.E.; CARVALHO, A.M.; PRAXEDES, M.A.; SANTOS, M.C.; FERNANDES, F.C. Crescimento inicial de cultivares de cafeeiro com diferentes doses de nitrogênio, fósforo e potássio. Coffee Science, Lavras, v. 12, n. 4, p. 552 - 561, out./dez. 2017.