EFFECT OF COVER CROPS AND BIOACTIVATORS IN COFFEE PRODUCTION AND CHEMICAL PROPERTIES OF SOIL

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ABSTRACT: Coffee cultivation has great socio-economic relevance in Brazil for the employment and income generation and there is currently a constant search for sustainable management techniques. Among them, we can mention the use of cover crops and soil bioactivators. However, studies relating the use of these two techniques are still incipient. Based on this, the objective of this research was to evaluate the effect of the Penergetic® bioactivator associated with different cover crops on chemical properties of soil and coffee productivity. The experiment was carried out in a coffee field with Catuaí Vermelho cultivar IAC 144, in a randomized block design in a factorial scheme 4 (soil cover) x 2 (use or not of the Penergetic® bioactivator), consisting of control (without plant cover); oats (*Avena strigosa*) + forage turnip (*Raphanus sativus*); oats (*Avena strigosa*) + forage turnip (*Raphanus sativus*) + lupine (*Lupinus albus*) + rye (*Secale cereale*) + vetch (*Vicia sativa*); *Brachiaria brizantha* (*Urochloa brizantha*), associated or not with the use of the Penergetic® bioactivator. The experiment was conducted for 6 months and after that period, the chemical properties of soil, the nutrient contents of the coffee plants, the development of the branches and the coffee productivity were analyzed. Data were analyzed by the Scott Knott test at 5% probability. It was verified the interaction between cover crops and the use of the Penergetic® bioactivator, positively influencing soil chemical characteristics, coffee nutrition and productivity.

Index terms: Green fertilization, coffee nutrition, fertility.

EFEITOS DAS PLANTAS DE COBERTURA E BIOATIVADOR NA PRODUÇÃO DE CAFÉ E AS PROPRIEDADES QUÍMICAS DO SOLO

RESUMO: A cafeicultura apresenta grande relevância socioeconômica no Brasil pela geração de renda e empregos e atualmente verifica-se uma busca constante por técnicas de manejo sustentáveis, dentre as quais, podemos citar o uso de plantas de cobertura e de bioativadores de solo. No entanto, estudos relacionando o uso dessas duas técnicas ainda são incipientes. Baseado nisso, o objetivo desta pesquisa foi avaliar o efeito do bioativador Penergetic® associado a diferentes plantas de cobertura nas características químicas do solo e na produtividade do cafeeiro. O experimento foi instalado numa gleba de café com a cultivar Catuaí Vermelho IAC 144, em delineamento de blocos casualizados em esquema fatorial 4 (cobertura do solo) x 2 (uso ou não do bioativador Penergetic®), sendo constituído por: Controle (sem planta de cobertura); aveia (*Avena strigosa*) + nabo forrageiro (*Raphanus sativus*); aveia (*Avena strigosa*) + nabo forrageiro (*Raphanus sativus*) + tremoço (*Lupinus albus*) + centeio (*Secale cereale*) + ervilhaca (*Vicia sativa*) ; *Brachiaria brizantha* (*Urochloa brizantha*), associados, ou não ao uso do bioativador Penergetic®. O experimento foi conduzido por 6 meses e após esse período foram analisadas as características químicas do solo, teores de nutrientes foliar das plantas do cafeeiro, desenvolvimento dos ramos e a produtividade do cafeeiro. Os dados foram analisados pelo teste de Scott Knott a 5% de probabilidade. Foi verificada a interação entre plantas de cobertura e o uso do bioativador Penergetic® influenciando positivamente as características químicas do solo, na nutrição e produtividade do cafeeiro.

Termos para indexação: Adubação verde, nutrição do cafeeiro, fertilidade.

1 INTRODUCTION

Most Brazilian soils present low natural fertility (SOUSA and LOBATO, 2004), associated with high acidity and aluminum concentration, therefore requiring high doses of correctives and fertilizers to guarantee satisfactory production (CARVALHO et al., 2017), however, there is an increase in costs once that fertilizers are mostly imported (RODRIGUES et al., 2015).

Coffee stands out among the crops of great economic importance, and Brazil is the world's largest producer and exporter (SUPLICY, 2013), with an estimated harvest of approximately 60 million bags in 2018 (CONAB, 2018). Coffee is considered a highly nutrient-demanding crop, requiring adequate soil fertility management in order to achieve nutrient balance and high productivity. This culture is the one with the lowest nutrient utilization among large crops according to Stipp and Casarin (2012).

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Cover crops are presented as an ecological practice and with lower costs for agricultural management, promoting balance in the physical, chemical and biological characteristics that compound the soil-plant system. Besides being an organic fertilizer alternative without great resources, they can be grown in the same environment where they will be produced for this purpose (SOUZA et al, 2008). Several species are recommended for cultivation between the lines of coffee with this objective, as reported by Matos et al. (2008).

In relation to soil fertility, the use of green fertilization contributes to the increase of organic matter and the effective (cation exchange capacity) CEC of the soil due to the availability of negative loads. Most of the green fertilizers are legumes, which establish symbiosis with rhizobia, reducing the cost with nitrogen fertilizers (SILVA, 2015).

Another strategy that has been used with the proposal to reduce the need for chemical fertilizers are the soil bioactivators, which are constituted by organic substances, humic and fulvic acids, amino acids, algae extract and vitamins, which may or may not, being associated with micronutrients (CASTRO et al., 2007). These products act in plant development by various mechanisms, such as ion transport and enzymes responsible for metabolism, which may influence the secondary metabolism, promoting the synthesis of precursors of important plant hormones and, consequently, contributing to plant nutrition (CASTRO et al. al., 2007). Külen et al. (2011) state that they act in all stages of the development of cultivated plants, and can benefit different crops, such as soybeans, corn, wheat, and vegetables. These substances may also contribute to seed germination (O'BRIEN, FOWKES e BASSOM., 2010).

The Penergetic® bioactivator has been used in Brazil and, among its mechanisms of action, it is possible to highlight the greater soil microbiota balance, increasing the organic matter decomposition and the nutrient cycling, reducing the use of inputs, thus contributing for the sustainability of the agroecosystem (CALEGARI, 2013). However, despite all the benefits of green manuring and bioactivators, studies involving the use of these two techniques are still incipient. Based on this, this research aims to evaluate the effect of the Penergetic® bioactivator associated with different cover crops on soil chemical characteristics and coffee productivity.

2 MATERIAL AND METHODS

The experiment was carried out at Farm Boa Esperança, located in Serrania, South of Minas Gerais, in 2016, from May to December. The experimental area has the following geographical coordinates: Latitude: 21 ° 36'18.29 "S, Longitude: 46 ° 07'46.29 ° W and 982 m Altitude. The selected coffee farm, cultivated with Red Catuaí IAC 144, was planted in 2011, spacing 3.5 m between rows and 0.7 m between plants.

The experimental design was a randomized complete block design in a 4x2 factorial scheme, with 4 treatments containing or not cover plants, distributed as follows: control treatment, without cover plant, with traditional farm management (weed control by chemical and mechanical); treatment containing oats (*Avena strigosa*) + forage radish (*Raphanus sativus* L); (*Lupinus albus*) + rye (*Secale cereale*) + vetch (*Vicia sativa*) (ANTCE) and the treatment containing only brachiaria (*Brachiaria brizantha*) as cover plant. All of these treatments were associated or not with Penergetic® soil bioactivator product. Four replicates per treatment were used, with a total of 32 experimental plots. Each plot of the experiment was constituted by 10 plants, being considered as a useful plot the six central plants for evaluation.

The planting densities of the cover plants were: brachiaria and forage turnip, 10 kg ha^{-1}, oats 40 kg ha^{-1}, lupine and rye 20 kg ha^{-1} and vetch 15 kg ha^{-1}. The bioactivator was used at a dose of 0.6 kg ha^{-1}, as recommended by the manufacturer.

Before the installation of the experiment, samples of soils in the 0 - 10 cm and 10 - 20 cm layers were carried out to carry out the chemical analysis, according to table 1.

The cover plants were kept in the area from May to October, a time that was mowed, and kept on the coffee tree line. Two months later, soil samples were removed in the 0-10 cm and 10-20 cm layers to perform the fertility analysis.

In the same period, leaves were collected in the middle third of the plants, where the fourth pair of leaves were removed from both sides of the plant and, subsequently, the plants were sent to the laboratory for analysis of nutrient contents, according to Silva (2015). The number of internodes of the plagiotropic branches was also evaluated. Six lateral branches were randomly selected at the height of the middle third in six plants of each plot. It was also evaluated the number of internodes developed in the period (ALFONSI, 2008).

TABLE 1 - Result of soil chemical analysis 0 - 10 cm and 10 - 20 cm depth in the installation in the experiment.

Chemical Parameters	0 - 10 cm	10 - 20 cm
pH ($CaCl_2$)	5,8	5,6
MO (g/kg)	30	27
P ($mmol_c/dm^3$)	77	22
K^+ ($mmol_c/dm^3$)	5,7	4,4
Ca^{2+} ($mmol_c/dm^3$)	62	45
Mg^{2+} ($mmol_c/dm^3$)	27	18
H+Al ($mmol_c/dm^3$)	29	34
S ($mmol_c/dm^3$)	14	15
SB (mg/dm^3)	95	68
T (mg/dm^3)	123	102
V (%)	76,9	66,6
Cu^{2+} (mg/dm^3)	4,4	2,6
Fe^{2+} (mg/dm^3)	72	81
Mn^{2+} (mg/dm^3)	5,8	4,2
Zn^{2+} (mg/dm^3)	4,5	2,5
B (mg/dm^3)	0,98	0,64

In order to evaluate the productivity, six plants of each plot were collected, measuring the drying and processing of the coffee. and later the classification and the granulometry to determine the percentages of sieve 16 coffee were performed according to Brazil (2003).

The data were submitted to the Scott Knott test at 5% of probability, using the Sisvar computer program (FERREIRA, 2011).

3 RESULTS AND DISCUSSION

For the results presented in the chemical analysis of the soil, performed in the 0-10 cm depth layer, all verified parameters, except for sulfur, presented significant interaction between soil cover and use of the Penergetic® bioactivator (Table 2).

Regarding the pH values, it was verified that, with the use of the bioactivator, no alteration of soil pH occurred. However, without the use of bioactivator, the pH was modified, and the highest value was observed in the control treatment, and the lowest in the soil cultivated with oats + turnip + lupine + rye + vetch (ANTCE).

These results can be justified by the cultivation of green manure plants, which, although favoring the cycling of nutrients and the decomposition of the organic material by soil microorganisms, promote a reduction of pH at the beginning of the process (OLIVEIRA, 2005).

When the action of the bioactivator is observed within the treatments, it is noticed that in the control treatment and with brachiaria there were significant differences in some of the evaluated parameters. In the control treatment, in the absence of the bioactivator, the pH was higher and the CTC lower when compared to its presence. In the treatment with brachiaria, it was possible to observe that in the presence of the bioactivator, the pH was lower, but the contents of CTC and Organic Matter were higher when compared to the treatment where there was no use of the bioactivator. For the coverage plants ANTCE the bioactivator had a superior effect compared to the same plant without its use.

Regarding the values of organic matter, no statistical difference was observed in the different soil cover treatments in the presence of the bioactivator. In the absence of the bioactivator, the soil cultivated under brachiaria presented lower value. However, according to Bressan et al. (2013), nutrient content and organic matter levels were higher in the areas covered by millet and brachiaria, and these plants were similar in relation to changes in soil chemical attributes.

TABLE 2 - Chemical parameters of soil samples collected in the 0-10 cm layer, in the interline of coffee plants grown under different cover crops, associated or not with the use of the Penergetic® bioactivator.

Chemical parameters	Bioactivator	Control	Oat and turnip	ANTCE*	Brachiaria
pH ($CaCl_2$)	With	4,48 A b	4,33 A a	4,73 A a	4,53 A a
	Without	5,50 A a	4,35 B a	3,95 C b	4,63 B a
MO (g dm^{-3})	With	30,25 A a	28,00 A a	27,25 A b	29,50 A a
	Without	30,25 A a	29,25 A a	30,25 A a	25,25 B b
V (%)	With	58,50 A a	33,50 Ba	68,50 A a	51,50 A a
	Without	70,50 A a	33,25 Ba	30,50 B b	45,25 B a
Potential Acidity mmolc/dm^3	With	44,00 A a	46,25 A b	33,00 A b	54,25 A a
	Without	31,00 C a	70,50 A a	82,00 A a	54,25 A a
Sum of bases mmolc/dm^3	With	64,33 A a	63,15 A a	71,55 A a	56,92 A a
	Without	74,60 A a	42,03 B b	35,75 B b	43,38 B a
CTC potential mmolc/dm^3	With	116,25 Aa	120,00 A a	104,50 B b	120,25 A a
	Without	106,00 Bb	115,75 A a	118,00 A a	101,50 B b

Average followed by distinct letters, uppercase in the row and lowercase in the column, differ by Scott Knott's test at 5% probability. * Abbreviation of treatment: oats + turnip + lupine + rye + vetch.

Analyzing the interaction between soil cover *versus* bioactivation, it was observed that the treatment of oat + turnip + lupine + rye + vetch (ANTCE) showed a lower value of organic matter in the presence of the bioactivator. According to Calegari (2013), these results occur because of this product favoring the soil microbiota and, consequently, the decomposition of organic matter.

In addition, in this treatment, lupine and vetch may have contributed to reducing the C/N ratio, favoring the decomposition of organic matter justifying the lower values of this parameter. Cunha et al. (2011), researching cover plants as: crotalaria (*Crotalaria juncea*), pigeonpea (*Cajanus cajan* (L.), (*Mucuna aterrima*), sorghum broom (*Sorgum technicum*) in fallow on the physical attributes of soil cultivated with organic beans and com under direct seedding and conventional preparation verified that although providing a good amount of biomass did not reflect the increase in the increase of the organic matter since this also depends on the quality of the residues, the C/N ratio, recalcitrant among other factors for its increase.

When observing the different types of soil cover without the bioactivator, the treatments oats + turnip and oats + turnip + lupine + rye + vetch (ANTCE) presented higher values of potential acidity. Tomé Júnior (1997 apud Paulett, 2012) confirms the trend of higher values of potential acidity ($H + Al^{+3}$) in soils with higher organic matter content, especially in more acidic soils.

Regarding the saturation of bases, when the bioactivator was used, only the oat + turnip treatment presented a lower result than the others. However, without the use of the bioactivator, the soils cultivated with the different cover plants were statistically inferior to the control treatment.

As for the effect of the bioactivator on the different cover plants, it was observed that the only treatment in which interaction occurred was oat + turnip + lupine + rye + vetch (ANTCE), and the bioactivator promoted a higher base saturation value. The same was observed by Callegari et al. (1993), which states that cover plants provide increased base saturation promoting soil fertility improvement by reducing the oxidation rate of organic matter in the soil.

For the soil analyzes collected in the 10-20 cm layer, the values of pH, organic matter, phosphorus, potassium, magnesium, and sulfur showed the interaction between soil cover versus the use of the bioactivator, as can be observed in table 3.

Regarding pH, in the presence of the bioactivator, the control treatment was the one with the lowest value. In the absence of the bioactivator, the soil cover with *Brachiaria* spp. promoted a lower pH value, a similar result for the 0-10 cm layer (Table 2). Analyzing the interaction between the soil cover *versus* the bioactivator, it was verified that the only treatment that showed influence was the control treatment, in which the use of the bioactivator reduced the pH of the soil, as observed for the 0-10 cm layer.

For the organic matter contents, the use of the bioactivator provided higher levels in the control and ANTCE treatments. In the absence of the bioactivator, the highest values were observed in the oat and turnip and ANTCE treatments.

In relation to phosphorus, with the use of the bioactivator, the highest value was for the soil covered with oats, turnip, lupine, rye and vetch (ANTCE). When the bioactivator was not used, the highest values in the phosphorus contents were for the control and oat and turnip treatments. Analyzing the interaction between soil cover *versus* bioactivator, it was observed that the bioactivator® worked positively, increasing phosphorus levels, in the treatments containing ANTCE and Brachiaria. According to Tirloni et al. (2009), bioactivators reduce phosphorus adsorption sites, increasing their availability in the soil for plants.

TABLE 3 - pH value and organic matter content of soil analyzes collected in the layer 10-20 cm, in the interline of coffee plants grown under different cover crops, associated or not with the use of the Penergetic® bioactivator

Chemical Parameters	Bioactivator	Control	Oatmeal + turnip	ANTCE*	Brachiaria
pH ($CaCl_2$)	With	4,30 Bb	4,65 Aa	4,85 Aa	4,90 Aa
	Without	4,98 Aa	5,00 Aa	4,85 Aa	4,50 Ba
Organic matter (g/dm^3)	With	27,50 Aa	24,00 Bb	28,25 Ab	25,75 Ba
	Without	27,00 Ba	30,00 Aa	31,50 Aa	24,25 Ca
Phosphor (mmolc/dm^3)	With	15,25 Ca	17,00 Cb	137,50 Aa	81,50 Aa
	Without	33,50 Aa	47,50 Aa	24,00 Bb	13,75 Cb
Potassium (mmolc/dm^3)	With	4,40 Aa	2,95 Bb	3,30 Ba	3,03 Ba
	Without	3,01 Bb	4,90 Aa	3,50 Ba	2,09 Ba
Magnesium (mmolc/dm^3)	With	7,00 Bb	6,50 Ba	15,25 Aa	7,50 Ba
	Without	11,75 Aa	7,00 Ba	5,75 Bb	5,75 Ba
Sulfur (mmolc/dm^3)	With	6,00 Aa	5,50 Aa	7,00 Aa	8,75 Ab
	Without	4,50 Ba	6,75 Aa	3,75 Ba	20,25 Aa

Means followed by distinct letters, uppercase in the row and lowercase in the column, differ by Scott Knott's test at 5% probability. * Abbreviation of treatment: oats + turnip + lupine + rye + vetch.

Potassium showed a statistically significant difference between the treatments, if it was superior to the coverings oats + turnip and the control treatment, however, in relation to the bioactivator, the control treatment was statistically superior when compared to the use of the bioactivator.

Magnesium in the ANTCE treatment with the use of the bioactivator was shown to be statistically superior, showing effect both in the coverage plant and in the use associated to the bioactivator.

For the phosphorus, the bioativador the highest levels were found in the treatments with Oat + turnip and in the consortium Oat + turnip + lupine + rye + vetch. When comparing the results of the treatments with and without bioactivator, it was observed that the product provided higher phosphorus contents in the *Brachiaria* and Oat + turnip + + rye + vetch plots, corroborating with Foloni et al. (2008) that *Brachiaria* presents high capacity in the recycling of P. Pavinato and Rosolem (2008), on the other hand, they showed the possibility of solubilization of phosphorus of the soil, in less labile forms, in the presence of plant residues, which may have occurred in the plots of the consortium between Oat + turnip + lupine + rye + vetch and in the treatment with *Brachiaria.*

The values of calcium, base sum, CTC and base saturation of the soil analysis results collected in the 10 to 20 cm depth profile did not show interaction with or without the use of the bioactivator (Table 4), having only soil cover influence.

Observing the values shown in Table 4, of the calcium contents, the treatments Control and ANTCE were the ones that presented better results, being statistically equal among themselves. The same can be observed for the other parameters (base sum, CTC and base saturation).

For the results of leaf analysis, there was a significant interaction for the nitrogen, potassium, calcium, magnesium, sulfur, boron, iron and manganese contents. The values for zinc were significant only for cover plants, while the phosphorus and copper contents were not significant, as shown in Tables 5 and 6.

The results of the plant tissue analysis showed that, in relation to the Nitrogen element, without bioactivator the treatments did not differ statistically. On the other hand, with the use of the bioactivator it was verified that the N was lower in the treatments with Oat + turnip, demonstrating that no interaction occurred.

For the potassium nutrient, the interaction of the bioactivator, with a statistical difference, occurred only for the treatment with Brachiaria, and among the cover plants, the lowest statistically found result was with *Brachiaria*.

In relation to Calcium, the treatments with bioactivator use were higher than Brachiaria without this association.

When considering Magnesium, the best treatments were oats + turnip and oats + turnip + lupine + rye + vetch without bioactivation and oats + turnip using bioactivator. It is also evidenced that the ANTCE was higher without the bioactivation when compared to the same treatment with the use of the bioactivator.

For the data of the Sulfur, the Control and Oat + turnip and oat + turnip + lupine + rye + vetch with bioactivators showed statistical differences. The treatments Oats + turnip and oats + turnip + lupine + rye + vetch and Brachiaria without the use of the bioactivator did not differ among themselves. However, in the control treatment the presence of the bioactivator showed positive response, with higher results than the treatment without bioactivator, however, *Brachiaria,* the bioactivator had no positive interaction.

TABLE 4 - Values of calcium, base sum, CTC and base saturation of soil samples collected in the layer 10-20 cm, in the interline of coffee plants grown under different cover plants.

Soil cover	Calcium mmolc/dm^3	Base sum %	CTC mmolc/dm^3	Base saturation %
Control	41,38 A	57,46 A	104,75 A	58,13 A
Oat and turnip	34,00 B	47,34 B	96,88 B	48,63 B
ANTCE*	49,00 A	65,15 A	107,50 A	61,25 A
Brachiaria	32,38 B	41,99 B	93,88 B	44,38 B

Averages followed by letters differ from one another by the Scott Knott test at 5% probability. * Abbreviation of treatment: Oats, Turnip, Lupine, Rye and Vetch.

TABLE 5 - Foliar contents of the macronutrients nitrogen, potassium, calcium, magnesium and sulfur of coffee plants grown under different cover crops, associated or not with the use of the Penergetic® bioactivator.

Chemical Parameters	Bioactivator	Control	Oatmeal + turnip	ANTCE*	Brachiaria
Nitrogen (g/Kg)	With	27,79 Aa	22,64 Bb	28,34 Aa	30,75 Aa
	Without	27,41 Aa	26,88 Aa	29,86 Aa	28,38 Aa
Potassium (g/Kg)	With	23,31 Ab	22,94 Ab	23,44 Aa	25,00 Aa
	Without	26,56 Aa	25,50 Aa	25,00 Aa	22,50 Bb
Calcuim (g/Kg)	With	9,06 Aa	9,13 Aa	8,69 Aa	8,81 Ab
	Without	8,60 Ba	8,69 Ba	9,13 Aa	10,00 Aa
Magnesium (g/Kg)	With	2,92 Ba	3,38 Aa	3,02 Bb	3,013 Ba
	Without	3,05 Ba	3,022 Ba	3,52 Aa	3,024 Ba
Sulfur (g/Kg)	With	2,39 Aa	1,87 Ba	2,44 Aa	1,78 Ba
	Without	1,59 Bb	1,56 Ba	2,46 Aa	2,07 Aa

Average followed by distinct letters, uppercase in the column and lowercase in the row, differ by Scott Knott's test at 5% probability. * Abbreviation of treatment: Oats, Turnip, Lupine, Rye and Vetch.

TABLE 6 - Foliar contents of boron, iron and manganese micronutrients of coffee plants grown under different cover crops, associated or not with the use of the Penergetic® bioactivator.

Soil cover	Boron (mg/Kg)		Iron (mg/Kg)		Manganese (mg/Kg)	
	With Bio	Without Bio	With Bio	Without Bio	With Bio	Without Bio
Control	79,21 A a	63,46 A b	138,25 A a	132,50 A a	140,75 A a	111,38 A b
Oat and turnip	63,92 B a	67,10 A a	138,25 A a	118,25 A b	119,25 B a	110,25 A a
ANTCE*	61,92 B b	73,64 A a	131,50 A a	100,00 B b	132,50 A a	116,25 B a
Brachiaria	69,67 A a	69,03 A a	120,00 A a	117,50 A a	112,50 B a	124,00 A a

Averages followed by distinct letters, uppercase in the column and lowercase in the row, differ by Scott Knott's test at 5% probability. * Abbreviation of treatment: Oats, Turnip, Lupine, Rye and Vetch

For the Boron element, in the presence of the bioactivator the control treatment presented higher results than the others, being also superior to the same treatment in the absence of the bioactivator. Regarding iron, in the treatment with bioactivator there was no statistical difference between the different sources of cover in the soil, however, in the absence of the product, the ANTCE treatment was the one that presented the lowest result. Analyzing the interaction, it was verified that the bioactivator had a positive effect when associated with oat and turnip treatments and ANTCE.

In relation to the Manganese, it was observed that the control treatment with bioactivator use was superior to the others, whereas in the absence of the product there was no significant difference between the treatments. Analyzing the effect of the bioactivator, there is a positive effect on the control treatment.

Table 7 shows the results obtained with respect to the zinc micronutrient.

Regarding Zinc, only the soil cover was significant, and the treatments oats and turnip and ANTCE cultivated in the coffee interlayer provided higher levels of this micronutrient in the coffee leaves.

Table 8 shows the number of internodes developed in the period, coffee production per plant and productivity.

Regarding the number of internodes, in the presence of the bioactivator, all the treatments cultivated with cover plants were superior to the control treatment. Analyzing the interaction, it was verified that the bioactivator had a positive effect when associated with Brachiaria.

TABLE 7 - Zinc leaf contents of coffee plants grown under different cover crops

Soil cover	Zinc(mg/Kg)
Control	10,83 B
Oat and turnip	14,19 A
ANTCE*	15,75 A
Brachiaria	11,63 B

Averages followed by distinct letters differ from one another by the Scott Knott test at 5% probability. * Abbreviation of treatment: Oats, Turnip, Lupine, Rye and Vetch.

TABLE 8 - Number of internodes and productivity coffee (bags ha-1) yield under different cover crops, associated or not with the use of the Penergetic bioactivator

Soil cover	Number of internodes		Productivity (bags ha^{-1})	
	With Bio	Without Bio	With Bio	Without Bio
Control	5,91 B a	5,99 A a	16,74 C a	14,91 C a
Oat and turnip	5,99 A a	5,87 B a	25,10 B a	19,21 B b
ANTCE*	6,37 A a	5,91 B a	26,54 B a	21,08 B b
Brachiaria	6,91 A a	5,80 B b	30,19 A a	30,20 A a

Averages followed by distinct letters, uppercase in the column and lowercase in the row, differ by Scott Knott's test at 5% probability. * Abbreviation of treatment: Oats, Turnip, Lupine, Rye and Vetch.

This data confirms Partelli's (2013) apud Dubberstein et al., (2017) demonstrating that a greater number of internodes comes from the longer productive branches that promote the production of more rosettes, allowing a greater emission of flowering buds leading to a greater quantity of fruits in the plant.

Analyzing coffee productivity, it was verified that the cover treatment with Brachiaria was superior to the others, both in the presence and absence of the bioactivator. Analyzing the interaction, the bioactivator had a positive effect on ANTCE and oat and turnip treatments.

4 CONCLUSIONS

It was observed that the bioativador promotes effect on soil chemical characteristics, nutrition and productivity of coffee, however, these results were variable according to the cover plant cultivated in the coffee plant.

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