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REGULAR ARTICLE

Distance of brachiaria management in between the rows of coffee trees

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Abstract

Brazil is the world's largest coffee producer, but with the changes in climate that have occurred in recent years, the concern with soil management with cover crops has become important, since it configures a strategy that can contribute to the improvement of production systems. Brachiaria is one of the main species used in intercropping in coffee production to generate biomass and soil cover. The objective of this research was to evaluate the effect of the distance of brachiaria management in between rows of coffee trees. The research was carried out from 2016 to 2022 in a coffee plantation implanted in 2016 with the cultivar Catuai Amarelo IAC 62 associated with *Brachiaria ruziziensis*, in a randomized block design, with 6 treatments and 4 replications: T1- without brachiaria between the rows (control), T2 - management of brachiaria up to the projection of the coffee tree crown, T3 - management with 25 cm distance from the projection of the crown of the coffee tree, T4 - management with 50 cm away from the projection of the coffee tree crown, T5 - management with 75 cm distance from the projection of the coffee tree crown, T6 - management with 100 cm distance from the projection of the coffee tree crown. The evaluated parameters were: setting and establishment of coffee seedlings, height of the orthotropic branches, length of the plagiotropic branches, number of internodes, and productivity. The intercropping of the coffee tree with brachiaria must be managed at 50 cm from the projection of the plagiotropic branch of the coffee tree, aiming at non-competition and better development of the crop.

Keywords

Biomass; *Coffea arabica*; soil covering; soil protection and improvement; Productivity.

Introduction

Changes in climate are being observed in agricultural production systems, especially coffee growing, with irregularities in the distribution of rainfall and increasingly frequent dry periods. Ragassi et al. (2013) point out that planting intercropped coffee with Brachiaria, in addition to biomass production, also brings benefits in relation to the chemical attributes of the soil, as well as in the storage and infiltration of water in the soil, in addition to the reduction of soil temperature, which positively interferes in the development of the coffee tree.

Brachiaria it is a forage grass with specific characteristics, such as being a polyploid, perennial grass, with apomictic reproduction (Bogdan, 1977). Its excellent vegetative vigour, high productivity, with cespitous growth, good tolerance to drought and cold stand out, these plants can reach 0.70 m. In systems with medium/high fertility, brachiaria can produce 10 to 15 tons of dry matter per ha^{-1}. It is a demanding cultivar in terms of soil fertility, whose development requires levels of base saturation between 50% and 60% with a sowing rate of 3 to 5 kg/ha^{-1} interspersed with the coffee tree, also requires precipitation of around 900 mm, with average response to fertilization.

It is necessary to point out that the population of weed species in coffee plantations is influenced by soil characteristics and variations related to climate, where weed management is also a selection factor, since weeds survive and multiply under influence of a constant type of control. As such, the cultivation of signalgrass between the rows of the coffee plantation still provides a large amount of plant material, which is slowly degraded, as it has a high carbon/nitrogen ratio and long fibres, benefiting the soil, where it will be covered for a longer period. In addition, the root system of this forage is extremely developed, thus contributing to the structuring of the soil and the prevention and elimination of erosion (Santos et al., 2014).

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It is also noteworthy that the mulch significantly conserves the soil and water of the coffee plantation, protecting the soil from high temperatures and rainfall, enriching it with organic matter and some nutrients, which will contribute positively to the production of coffee. Additionally, the cover will promote the inhibition of weeds either by competition (shading), or by allelopathy, through their released allelochemicals, something that also occurs with other cover species or with a mix of different cover species (Calegari, 2016; 2018a; 2018b), and it continues to happen even when the brachiaria is dead, via leaching into the soil (Santos et al., 2014).

Currently, the concept of improving the soil and intercropping with cover crops between the coffee rows has been widely adopted and allows for several benefits, although most coffee growers still manage their crops in completely clean conditions. However, this management needs to be very technical, so that it does not lead to weed competition, since according to Alcantara and Ferreira (2009), weed competition can significantly affect the production of the coffee crop.

Therefore, the objective of this work was to evaluate the effects of the distance of brachiaria in relation to the interrows of coffee trees.

Materials and methods

The experiment was conducted on a coffee farm located in the south of Minas Gerais State, Brazil, between October 2016 and May 2022. The experimental area is located in the following geographic coordinates: latitude 21°36'18.29" S, longitude 46°07'46.29" W, and altitude of 1077 m. The characteristic climate of the region is Cwb, that is, hot and temperate, with a lower rainfall rate in winter than in summer. The city average annual temperatures are around 19.1ºC, while annual precipitation is of 1730 mm (Climatedata-org, 2022). The soil is characterized as red and yellow latosol, medium texture with 21% sand, 39% clay, 40% silt according to Santos et al. (2018).

In March 2016, soil preparation was carried out with plowing and harrowing of the area. In addition, a collection of 20 soil sub-samples was carried out in the 0-20 cm layer with the aid of a Dutch auger. Subsequently, the collected samples were mixed, giving rise to a composite sample which was later analysed in the laboratory to verify the nutrient content in the soil, the results of which are shown in Table 1.

Table 1. Result of the initial soil analysis at a depth of 0-20 cm, Campestre/MG (2016).

pH		**Prem**	**P**	**K**	**V**	**m**	**MO**
(H_2O)	*($CaCl_2$)*	*(mg/L)*		*(mg/dm³)*	*(%)*		*(dag/kg)*
5.20	4.60	14.78	2.74	30.00	30.20	13.12	2.87

Ca	**Mg**	**Al**	**H + Al**	**T**	**Zn**	**Fe**	**Mn**	**Cu**	**B**	**S**
		(Cmolc/dm³)					*(mg/dm³)*			
1.67	0.64	0.36	5.50	7.89	2.20	45.70	10.60	0.90	0.30	1.10

Soil acidity was corrected using 90% dolomitic limestone to raise the base saturation to 70% according to the methodology proposed by Matiello et al. (2010) and Matiello et al. (2020). Furthermore, the fertilizations carried out during the experiment period were based on the recommendations guide for coffee cultivation in Brazil (Matiello et al., 2010; Matiello et al., 2020). According to soil analysis in the 0-20 cm layer, carried out annually, as well as estimates of pending load, all plots were submitted to the same fertilization, considering the plot as a commercial crop.

Pest and disease control was carried out with fungicide and insecticide soil applications (thiamethoxan + triazole) and annual fungicide foliar applications (triazole), at the dosage recommended by the guide. Soil application was carried out in November/December while foliar application was done in February. All plots received the same management.

The coffee cultivar implanted was Catuai Amarelo IAC 62 and the brachiaria cultivar used was *B. ruziensis*. Planting was carried out in 2016, with spacing of 3.5 m x 0.5 m between coffee plants, totalling a plant stand of 5,714 plants/ha^{-1}.

The experimental design was in randomized blocks, consisting of 6 treatments and 4 repetitions, as follows: T1 - without brachiaria cultivation between the rows (control), T2 - brachiaria management up to the projection of the coffee tree crown, T3 - management with 25 cm distance from the projection of the coffee tree crown, T4 - management with 50 cm distance from the projection of the coffee tree crown, T5 - management with 75 cm distance from the projection of the coffee tree crown, T6 - management with 100 cm distance from the projection of the coffee tree coffee cup. This summed up to a total of 24 experimental plots, each plot consisting of 16 coffee plant, 10 of which (from the centre) were considered for the evaluations.

Planting of the brachiaria was carried out in October and December 2016, meaning that the coffee seedling planting was carried out while the brachiaria was already in development, also with the application of a pre-emergent herbicide (Oxyfluorfen 240 g/L^{-1}), (3 L/ha^{-1}) as costal pump (200 L/ ha^{-1}), with the mentioned distances (treatments) from the plagiotropic branches or from the tip of the leaves of the seedlings. As the coffee plants developed, the brachiaria was managed with the premise of maintaining the distance (treatment). The brachiaria was managed whenever it reached 50 cm in height, using a manual cutter and the biomass was maintained between the rows of the coffee tree. For the plots

that were maintained without coverage with brachiaria, it was managed across the rows using the herbicide.

In 2017, the evaluated parameters were: setting and establishment of coffee seedlings, height of the orthotropic branches, length of the plagiotropic branches, and number of internodes. From 2018 to 2019, the evaluated parameters were: height of the orthotropic branches, length of the plagiotropic branches, and number of internodes. From 2019 to 2022, the number of internodes was more emphasized, and productivity was also evaluated.

The production of green and dry biomass (ton/ha^{-1}), for this assessment, used a 1m^2 template, where it was thrown randomly into the plot, following the methodology proposed by Cavalcante et al. (2012). Mowing was done separately in this area and material was collected for evaluations. The results were extrapolated to the useful area of each treatment.

The data obtained were subjected to analysis of variance using the statistical software Sisvar® (Ferreira, 2014), with the significant difference between treatments determined by the F test, with means compared by the Scott-Knott test at a 5% probability level.

Results and discussion

For the setting of coffee seedlings under definitive planting conditions in the field, the treatment with the use of brachiaria in the projection of plagiotropic branches (0 cm) and without the use of soil cover resulted in the lowest levels of setting, even differing statistically from the others (Table 2).

Table 2: Mean values of seedling set-up (2017), length of plagiotropic branches, height of orthotropic branches, number of internodes (2017 - 2022), and productivity (2019 - 2022) of coffee crop under the effect of *B. ruziensis* in between coffee tree rows.

Evaluated parameters	2017					
	Without brachiaria	0 cm	25 cm	50 cm	75 cm	100 cm
Setting (%)	90 B	88 B	94 A	98 A	96 A	94 A
CV (%)	2.25					
Plagiotropic (cm)	42 B	40 B	55 B	63 A	50 B	49 B
CV (%):	6.52					
Orthotropic (cm)	56 C	55 C	69 B	77 A	60 C	62 B
CV (%)	9.33					
Internodes	6.1C	5.5C	7.5B	8.2A	7.2B	6.4C
CV (%)	11.34					

	2018					
	Without brachiaria	0 cm	25 cm	50 cm	75 cm	100 cm
Plagiotropic (cm)	92 C	85 C	104B	112A	101B	97B
CV (%):	14.37					
Orthotropic (cm)	104B	97C	108B	122A	100C	99C
CV (%)	8.66					
Internodes	5.5B	5.1B	6.4B	7.1A	6.0B	6.1B
CV (%)	5.21					

	2019					
	Without brachiaria	0 cm	25 cm	50 cm	75 cm	100 cm
Plagiotropic (cm)	133B	110C	140B	159A	139B	129B
CV (%):	12.67					
Orthotropic (cm)	141B	127C	153B	170A	147B	134C
CV (%)	15.82					
Internodes	6.2B	5.2C	6.9B	7.7A	6.3B	5.9C
CV (%)	9.45					
Productivity (bags/ha^{-1})	18.9C	17.2C	20.2B	25.6A	21.9B	20.3B
CV (%)	11.51					

	2020					
	Without brachiaria	0 cm	25 cm	50 cm	75 cm	100 cm
Internodes	4.9B	4.5B	5.1B	6.9A	5.2B	4.4B
CV (%)	5.33					
Productivity (bags/ha^{-1})	20.2C	19.5C	19.4B	28.7A	21.5B	20.9C
CV (%)	7.26					

	2021					
	Without brachiaria	0 cm	25 cm	50 cm	75 cm	100 cm
Internodes	5.2B	5.5B	6.2B	7.3A	6.1B	5.9B
CV (%)	6.85					
Productivity (bags/ha^{-1})	27.3B	27.4B	26.1B	35.9A	31.2B	28.2B
CV (%)	9.34					

	2022					
	Without brachiaria	0 cm	25 cm	50 cm	75 cm	100 cm
Internodes	6.0B	4.5B	5.0 B	6.9 A	5.85B	6.1B
CV (%)	6.13					
Productivity (bags/ha^{-1})	12.4B	10.4 B	11.3B	17.1A	12.1B	11.9B
CV (%)	13.67					

* Means followed by the same letters do not differ statistically by the Scott-Knott test at 5%.

Regarding plagiotropic, orthotropic, and internode growth, coffee plants submitted to brachiaria management with 50 cm of distance, promoted the best results.

The results obtained in the growth of the plagiotropic, orthotropic, and internode branches differed from the data reported in the research by Souza et al. (2006), where

management with distances smaller than 100 cm led to a reduction in plant height when compared to those with greater distances. Further, Ronchi (2002) points out that intercropped brachiaria cultivation close to the coffee plant leads to competition and harms the development of the coffee tree, affecting height and growth of branches. However, Ragassi et al. (2013) describe the benefits that the intercropping provides, in terms of improving water storage in the soil and reducing the effects of sunlight overheating the soil, which promotes a reduction in its metabolism and consequent interference in growth. Still, Alcântara and Ferreira (2009) point out that weed competition with the coffee tree significantly affects the growth of the crop.

Coffee trees managed with the presence of *Digitaria insularis* promote competition, which can impair the absorption of nutrients, in addition to reducing the development of new coffee trees by up to 40% (Carvalho et al., 2013). This statement shows that, if not properly managed, the use of brachiaria can lead to competition effects, even though there are benefits that the species provide to the soil.

According to the analysis of the accumulated production for the evaluation period (2019 to 2022), coffee cultivation alongside brachiaria with managements of 50 cm from the projection of plagiotropic branches promoted higher productivity than the others, differing statistically and promoting a differential, that is, varying from 20.6 to 32.8 bags/ha^{-1} in relation to the average. The result was positive in the order of 5.1 to 8.2 bags/ha^{-1}/year (Figure 1).

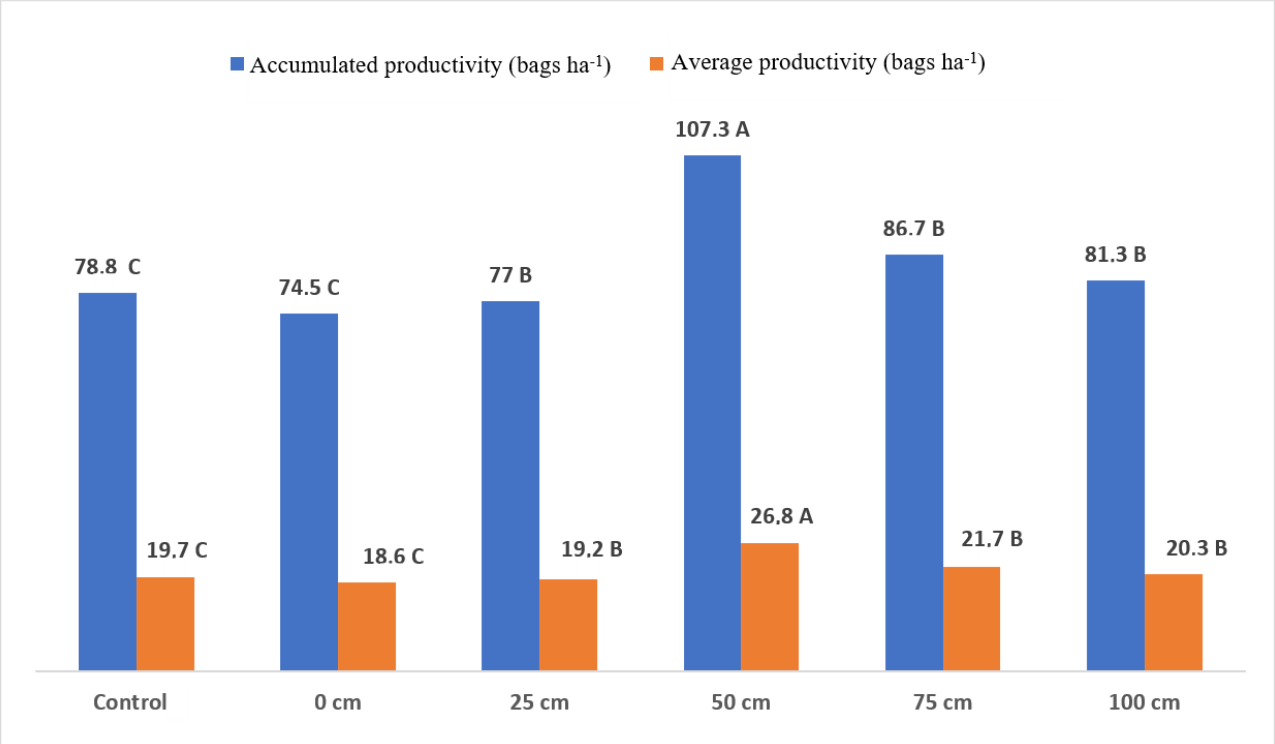

Figure 1. Average productivity and accumulated total for the period of 2019 to 2022.

*Averages followed by the same letters do not differ statistically from each other by the Scott-Knott test at 5%.

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Franco Junior et al. (2018) obtained results with brachiaria grown in association with coffee, with a productivity differential of up to 15 bags of processed coffee per ha^{-1}. Matiello and Lacerda (2017), in their research, reported that managing coffee crop with brachiaria resulted in a productivity of 16.3 bags/ha^{-1}, while plots managed with pre-emergent herbicides, keeping the soil completely clean, produced 23.7 bags/ha^{-1}. Given the divergences between the two works, it is possible to see the great importance of knowing how to manage these plants, especially regarding the conditions for using their benefits and preventing weed competition.

Alcântara and Ferreira (2009) also presented data where the competition of weeds with the coffee tree can reduce the productivity of adult crops by up to 20%. Moreover, according to a study carried out by Cofee and Climate (2019), the use of *Brachiaria ruziziensis* between the rows of coffee trees provided a productivity of 27.8 sc/ha^{-1}, which is 1.4 times higher than that produced by the area that was kept uncovered and managed only with the use of herbicides.

Regarding brachiaria biomass production, it was observed that under management (mowing), the treatments of 0-25 cm from the projection of the plagiotropic branches were the ones that produced the most biomass, both green and dry, even differing statistically from the other treatments (Figure 2). It is also noteworthy that the management without cover did not produce biomass, as it was managed with the use of herbicides (Figure 2).

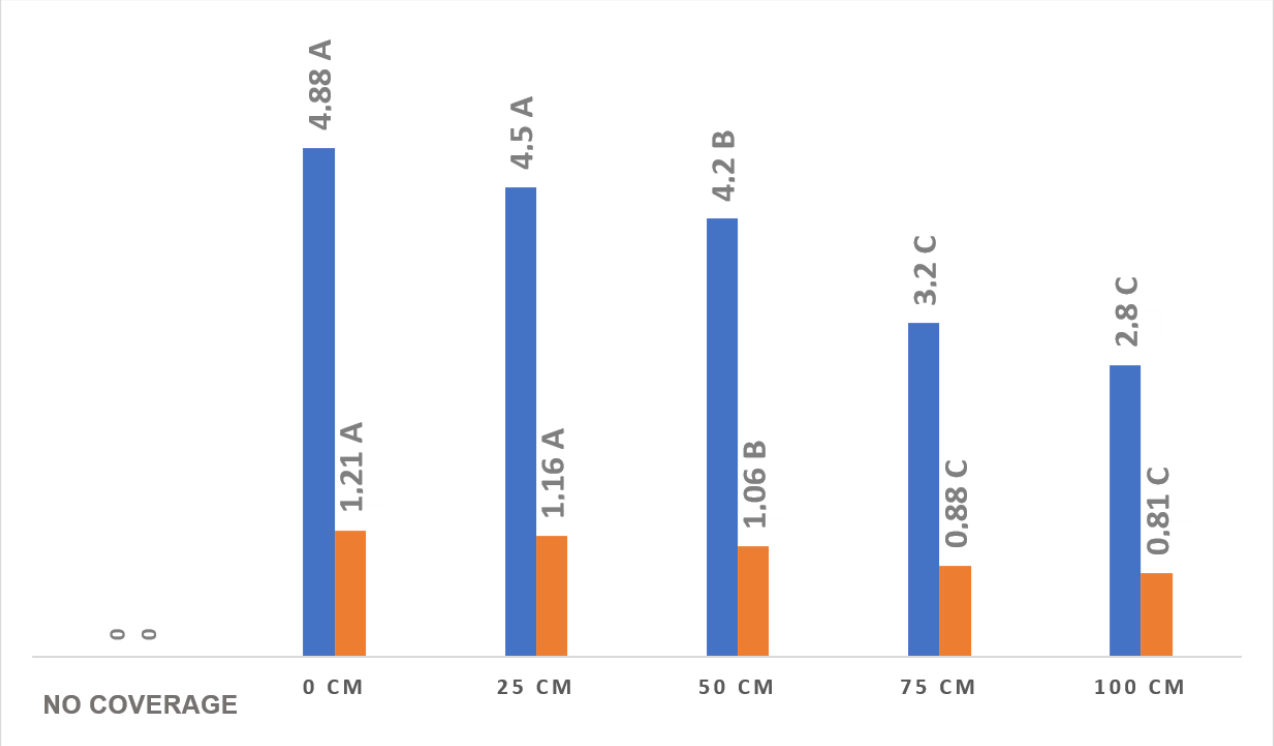

Figure 2. Average production of green and dry biomass (ton/ha^{-1}) per management (mowing).

Franco Junior et al. (2022) obtained a production of more than 9 tons of green biomass and 2.6 tons of dry biomass per ha^{-1}, for the research period. Under these conditions, also thinking about each management as it was evaluated in this one, the values are quite consistent, which allows us to say that *B. ruziensis* intercropped with coffee trees can produce about 4 to 5 tons of green mass per ha^{-1}.

Besides, Ragassi et al. (2013) also mention that the production of brachiaria biomass managed between coffee rows can result in up to 5 ton/ha^{-1}, which can contain up to 70 kg N/ha^{-1} and 8 kg K_2o/ha^{-1}.

Based on these data, we can consider that the management with 50 cm of the projection of the plagiotropic branches of the coffee tree produced practically the same value described, thus being a very technical management, in terms of allowing the best performances for the agronomic characteristics of the culture, as a good production of biomass, and even considering the availability of nutrients that it will provide.

Conclusions

It is concluded that intercropping coffee with brachiaria should be managed at 50 cm from the projection of the plagiotropic branch of the coffee tree, aiming at non-competition and better development of the crop. The management of the brachiaria at 50 cm from the projection of the plagiotropic branches of the coffee tree provided the best plant growth, especially regarding the plagiotropic branches, the number of internodes, and consequent productivity.

References

Alcântara, E. N.; Ferreira, M. M. (2009). Efeito de métodos de controle de plantas daninhas na produção de café durante 30 anos. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 6, Vitória. Anais. Brasília, DF: Embrapa Café, 2009. 1 CDROM.

Bogdan, A.V. (1977). Tropical pasture and fodder plants. New York :Longman, 475p.

Calegari, A. Plantas de cobertura. Manual Técnico. Fev. 2016. Penergetic. Uberaba, MG 24p. (3a. edição).

Calegari, A. Cover crops. In “Penergetic the natural Biotechnology. With the impulse of Nature. For intelligent Agriculture”. (2018a). Publisher: Penergetic International AG. Romiszelgstrasse. CH- 8590 Romanshorn. www.penergetic.com Graphic Design, Silvia Wasner. Switzerland. P. 07-33.

Calegari, A. Advantages in coffee planting when using cover crops and penergetic products. In “Penergetic the natural Biotechnology. With the impulse of Nature. For intelligent Agriculture”. (2018b). Publisher: Penergetic International AG. Romiszelgstrasse. CH- 8590 Romanshorn. www.penergetic.com Graphic Design, Silvia Wasner. Switzerland. P. 07-33.

Carvalho, L. B.; Alves, P. L. C. A.; Bianco, S. (2013). Sourgrass densities affecting the initial growth and macronutrient content of coffee plants. Planta Daninha, Viçosa, 31(1), 109-115.

Cavalcante, V.S.; Santos, V.R.; Santos Neto, A.L.; Santos, M.A.L.; Santos, C.G.; Costa, L.C. (2012). Biomassa e extração de nutrientes por plantas de cobertura. Revista Brasileira de Engenharia Agrícola e Ambiental, 16(5): 521-528. Doi: https://doi.org/10.1590/S1415-43662012000500008

Coffee and climate, Use of Brachiaria ruziziensis and Cajanus cajan as cover crops for coffee plantations Cofffe plaza, Hamburg Germania, 2019 pg 1-15 Acesso em 13/10/2022 disponível em https://toolbox.coffeeandclimate.org/wp-content/uploads/Case-Study-Brachiaria-as-Temporary-Shade-Trifinio.pdf

Ferreira, D. F. (2014). Sisvar: um guia dos seus procedimentos de comparações múltiplas Bootstrap. Ciência e Agrotecnologia, 38(2), 109-112.

Franco Junior et al. (2022). Coverage plants in the management of skeletal coffee. Revista Ceres, 69(3), 247-255.

Franco Junior et al. (2018) Effect of cover crops and bioactivators in coffee production and chemical properties of soil. Coffee Science, Lavras, 13(4), 559-567.

Matiello, J.B.; Santinato, R.; Garcia, A.W.R.; Almeida, S.R.; Fernandes, D.R. (2010). Cultura de Café no Brasil, Manual de Recomendações. Varginha, Procafé. 542p.

Matiello, J.B.; Santinato, R.; Garcia, A.W.R.; Almeida, S.R.; Fernandes, D.R. (2020). Cultura de Café no Brasil, Manual de Recomendações. Varginha, Procafé. 716p.

Matiello, J.B.; Lacerda, G. (2017). Efeito de sistemas de condução do mato, na entrelinha inicial de cafeeiros, no Sul de Minas. Embrapa Café. 1 (1). 1-2p.

Ragassi, C.F.; Pedrosa, A. W.; Favarin, J. L. (2013). Aspectos positivos e riscos no consórcio cafeeiro e braquiária. Visão Agrícola, 12(1), 29-32.

Disponível em:<https://www.esalq.usp.br/visaoagricola/sites/default/files/va12-instalacao-da-lavou

ra05.pdf>. Acesso em 16 de Nov. 2021.

Ronchi, C.P. (2002). Interferência e controle de plantas daninhas na cultura de café (Coffea arabica L.), 115 f. Dissertação (Mestrado em Fitotecnia) Universidade Federal de Viçosa, Viçosa.

Santos, J.C.F.; Costa, R.S.C.; Leônidas, F.C.; Mendes, A.M.; Rodrigues, V.G.S. (2014). Manejo agroecológico de plantas daninhas da cultura do café. Porto Velho, RO: EMBRAPA, Documentos 159, 28p.

Souza, L.S.; Losasso, P.H.L.; Oshilwa, M.; Garcia, R.R.; Goes Filho, L.A. (2006). Effect of Brachiaria decumbens control bands on the initial development and productivity of Coffea arábica. Planta Daninha, 24(4), 715-720.