Coverage plants in the management of skeletal coffee

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ABSTRACT

Currently, one of the most used practices in national coffee production is skeletal pruning, to preserve productive capacity, correct plant architecture, minimize the occurrence of diseases, among others. Also, it reduces the plants diameter, exposing the soil to climatic conditions, erosion, loss of moisture and nutrients, negatively affecting the development of coffee. The use of cover plants intercropped with coffee is presented as a technique to avoid and minimize these problems. Therefore, the objective of this research was to evaluate the effect of cover crops on the chemical and physical characteristics of the soil and the skeleton coffee tree. The experiment took place at Fazenda Boa Esperança, city of Serrania, South of Minas Gerais, from October/2017 to December/2018, in randomized blocks, composed of 8 treatments with and without cover crops. Three replicates per treatment were used, totaling 24 experimental plots, each with 14 plants, being the 10 central considered useful for evaluation. The cover crops contributed to the improvement of nutrient contents in the soil, maintained a better level of humidity and milder temperatures providing a greater development to the skeletonized coffee. They also positively influence weed control, but none could suppress all plants present in the research.

Keywords: coffee pruning; consortium; green manure; plagiotropic.

INTRODUCTION

Currently, one of the most used practices in national coffee growing is skeletal pruning in coffee plantations in production, especially for *Coffea arabica* species. This pruning model aims to preserve the productive capacity of the coffee tree, correct the architecture of the coffee trees, minimize the occurrence of certain diseases, promote the productive renewal of the plants, making the economic aspect viable and reducing the biennially common to the coffee species (Japiassú *et al*., 2010; Pereira *et al*., 2013). According to Scarpare Filho (2013), another reason why pruning is used in coffee plantations is the occurrence of climatic problems such as frosts, hailstorms, or prolonged drought.

After the development of this pruning model, the management system known as "*Zero Harvest*" was developed, allowing to maintain the size of the crop and promoting its recovery in years of negative biennially, in which the crop is very low, making the cost of the harvest high. Thus, the coffee grower starts to produce in cycles, harvesting only in the years of high production (Japiassú *et al*., 2010), in addition to maintaining higher average productivity.

In technical terms, this pruning model is drastic, promoting the elimination of practically all plagiotropic branches, also reflecting on the loss of about 70% of the root system, which will develop proportionally as the coffee canopy recovery occurs, which will normally be two years after the intervention (Thomaziello, 2013).

After skeletal pruning, there is a reduction in the leaf area of the coffee tree. Although there is a layer of organic matter on the soil, depending on the conditions of climate

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and management, this soil can be exposed to the weather, causing erosion, increased soil temperature, less moisture retention and loss of nutrients, promoting less development and initial production of coffee.

With the use of cover crops, several benefits have been shown to the coffee tree, this can also be a strategy to minimize these problems, contributing to the development of the skeleton coffee tree. Cover plants provide a milder temperature in the soil (Ragassi *et al*., 2013), improve the structure and infiltration of water in the soil (Moreira *et al*., 2016), contribute to the control of spontaneous herbs, including difficult-to-control plants that have already developed resistance to glyphosates, such as *Capim amargoso* and *vova* (Gemelli *et al*., 2012).

Cover crops also have the ability to decrease the population of phytonematodes, including with the same efficiency as the agrochemicals and biological products (Cardoso *et al*., 2014; Costa *et al*., 2014), promote the increase in the population of beneficial microorganisms (Presotto *et al*., 2014) and the accumulation of organic matter, reducing the use of synthetic N (Maluf *et al*., 2015), in addition to the cycling and accumulation of practically all mineral nutrients, according to several authors.

Therefore, the objective of this research was to evaluate the effect of cover crops on the chemical and physical characteristics of the soil and the skeleton coffee tree.

MATERIAL AND METHODS

The experiment was carried out at Fazenda Boa Esperança, located in the city of Serrania, South of Minas Gerais, from October/2017 to December/2018. The experimental area is in the following geographical coordinates: Latitude: 21°36’29.72"S, Longitude: 46°74’07.29"W and an altitude of 957m. The land is cultivated with the *Coffea arabica* cultivar Catuaí Vermelho IAC 144, planted in 2011 and skeletonized in September/2017, with a spacing of 3.5 m between rows and 0.7 m between plants.

According to Alvares *et al.* (2013) (Table 1), the climate is classified as cfb climate, which is observed in only 2.6% of Brazilian territory. The main occurrence of this climate is from southern Minas Gerais (Mantiqueira Mountain) and part of Rio de Janeiro and Espírito Santo to Rio Grande do Sul state (Araucarias Plateaus).

The soil is characterized as a Yellow Red Latosol and, according to the results of granulometric analysis, it has an average texture with 28% clay, 43% sand and, 29% silt, that is, type 2, according to the classification of the Ministry of Agriculture and Livestock and Supply - MAPA, (2008).

The experimental design was randomized blocks, composed of 8 treatments with and without cover plants, distributed as follows: control treatment without cover plants and with the traditional management of the farm where the management of spontaneous plants is chemical control and mechanical control (brush cutter and herbicide); *Crotalaria spectabilis*; *Cajanus cajan*; *Vigna unguiculata*; *Fagopyrum esculentum; Urochloa brizantha*; *Urochloa ruziziensеs* and Plant cocktail: *Crotalaria spectabilis spectabilis* + *Cajanus cajan* + *Vigna unguiculata* + *Fagopyrum esculentum* as a cover plant.

Three replicates per treatment were used, totaling 24 experimental plots. Each plot of the experiment consisted of 14 plants, the 10 central plants being considered as a useful plot for evaluation. The planting densities of cover plants were: *Crotalaria spectabilis* 10 kg ha^{-1}, *Cajanus cajan* 20 kg ha^{-1}, *Crotalaria spectabilis* 8 kg ha^{-1} + *Cajanus cajan* 18 kg ha^{-1} + *Vigna unguiculata* 6 kg ha^{-1}, *Fagopyrum esculentum* 18 kg ha^{-1}, *Urochloa ruziziensеs* 10 kg ha^{-1}, *Urochloa brizantha* 10 kg ha^{-1}.

Sowing was carried out 30 days after pruning. The plants that remain of the crop were crushed with the use of a brush cutter by a tractor to accelerate their decomposition and seeding of cover crops. For sowing a manual planter (*Matraca*) was used, with 3 interleaving lines being grown to the coffee tree with a spacing of 50 cm, considering the center of the street of the coffee as a reference point.

Before the installation of the experiment, just after mowing, soil sampling was done in layers 0-10 and 10-20 cm to perform the chemical analyses shown in Tables 8 and 9.

The cover plants were maintained in the area from October 2017 to April 2018, when a clearing was carried out through an ecological brush cutter and kept on the coffee tree’s lines. In April, the biomass production was surveyed, evaluating in samples of 1m² the biomass of the collected cover plants, analyzing the size and the green and dry weight of the aerial and root parts. The drying was carried out in an oven with forced air circulation at 70 °C. After drying, this material was subjected to analysis of nutrient content in plant tissue according to Marcante *et al.* (2010).

In April 2018, before the clearing, the phytosociological survey was also carried out on the plots (Table 2). Sampling of the weeds were randomly done in an area of 1m², following the methodology of Partelli *et al.* (2010). Then, there was the analysis of the parameters of relative density, relative abundance, relative frequency, and the importance value index (IVI). These are, according to Pitelli *et al.* (2000) the most relevant parameter for phytosociological survey.

The number of internodes in the plagiotropic branches were evaluated, with 10 lateral branches randomly marked at the height of the middle third in ten plants in each plot, the number of internodes developed in the period was evaluated as well (Colodetti *et al.*, 2018).

Infrared thermometer was used to evaluate soil temperature, (Embrapa, 2011), with measurements being taken at 1 pm, once a week, at a height of 50 cm from the ground. Averages were obtained from the values collected.

Soil moisture was determined by sampling, using a volumetric ring and leading to circulation forced air oven at 65 °C to examine the difference in weight between the collection and the end of the laboratory procedure (Embrapa, 2011). After the survey and tabulation, the data were subjected to the Scott-Knott test at 5% probability, using the computer program SISVAR® (Ferreira, 2014).

RESULTS AND DISCUSSION

Analyzing Table 3, the cover plants were distributed into four groups concerning the fresh matter, being *Crotalaria spectabilis* and *Cajanus cajan the ones with* plants were the ones with the greatest amount of biomass (green mass) per unit area, differing statistically from the others.

It also represents that regarding extracting the water content of the plants, the proportion between green and dry matter maintains the same statistical difference.

Table 4 shows the dry and green biomass obtained from the surveyed cover plants, disregarding the biomass of the root system, and it is noted the same pattern observed previously (Table 3), confirming that the root system of the cover plants is proportional to the aerial part, maintaining the same relationship and statistical difference both when analyze the plant's biomass as when its root system is extracted, with a similar proportion when analyzing dry biomass.

Table 5 shows the contribution of nutrients accumulated in the cover crops grown between the lines of the coffee tree. Regarding the content of nutrients accumulated in the dry biomass of the cover crops grown between the skeletal coffee lines, we can observe that, for nitrogen levels, among the cover plants, *Cajanus cajan* had higher accumulation, being statistically superior to the others.

These data corroborate the fact that legumes can perform symbiosis with Diazotrophic bacteria, which synthesize atmospheric N, releasing the nutrient to plants. In a short period, nitrogen will once again enrich the soil, reducing the demand for this element synthetically, relieving the production cost of commercial crops. Also, apart from the presence of BNF in the soil, the study showed their efficiency, which may be related to the good soil fertility and the organic matter, allowing the strains to establish and survive (Rufini *et al.*, 2014).

Table 3: Weight green mass and dry mass of aerial and root parts of cover plants intercropped with coffee

Treatments	***Green mass (ton.ha^{-1})***	***Dry mass (ton.ha^{-1})***
Brizantha	12.850 D	3.500 D
Buckwheat	17.000 C	4.666 C
Ruziziensis	9.666 D	2.633 D
Cocktail*	20.900 B	5.700 B
Vigna unguiculata	21.866 B	6.000 B
Cajanus cajan	30.900 A	8.466 A
Crotalaria spectabilis	31.733 A	8.700 A
CV (%)	**23.61**	**18.78**

*Cocktail (*Vigna unguiculata*, *Crotalaria spectabilis*, *Cajanus cajan* and Buckwheat). ** Means followed by the same letters in column do not differ significantly by the Scott-Knott Test at the 5% probability level.

Table 1: Climatological data of Serrania-MG during the study period

	Months											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average temperature (°C)	23	22.8	21.4	20	17.3	16.5	17.3	19.2	20.8	21.8	22.3	21.3
Minimum temperature (°C)	17.5	17.2	15.4	14	10.2	9	9.7	11.7	14.1	15.8	16.9	15.7
Maximum temperature (°C)	28.5	28.4	27.4	26	24.4	24	25	26.7	27.5	27.8	27.7	27
Precipitation (mm)	267	199	173	74	51	31	26	26	70	139	189	281

Table 2: Population of spontaneous herbs present in the field at the beginning of the experiment

Implementation	***Ipomoea purpurea***	***Conyza bonariensis***	***Bidens pilosa***	***Sonchus oleraceus***	***Mentha suaveolens***	***Digitaria insularis***
Relative D (%)	23.75	18.9	15	12.5	11.35	18.5
Relative F (%)	25.0	12.5	12.5	12.5	12.5	25.0
A Relative (%)	15.5	17.5	19.1	15.6	11.1	21.2
IVI	64.25	48.9	46.6	40.6	34.95	64.7

Relative D - Relative density, Relative F - Relative Frequency, A Relative - Relative abundance and IVI - Importance value index.

Including legumes in the crop rotation showed better results for N balance in the soil-plant system and to increase soil organic C content (Balota *et al*., 2014).

Regarding the P, K, Mg, Cu, and Zn content, between the groups formed, *Cajanus cajan* and *Crotalaria spectabilis* had higher values. The species that accumulated the highest Ca, Mn, and B content were *Crotalaria spectabilis*.

Table 6 shows the contribution of cover crops concerning the temperature and humidity of the soils in which they are grown. For the average soil temperature, the cover plants did not differ statistically from each other, however, they differed when compared to the soil without cover, noting that all species maintained temperatures favorable to the survival and development of the root system, which, according to Ragassi *et al.* (2013), is below 35 ºC.

Regarding soil humidity, analyzed by the gravimetric method, we show that the cover crops that influenced the higher water storage in the soil were buckwheat, brizanta, cocktail, and ruziziensis. It can also be emphasized that all species had statistical differences when compared to the soil without vegetation cover.

Santos *et al.* (2014), observed that the plants used as cover have a vigorous and fasciculate root system with a great capacity to penetrate and take advantage of nutrients in deeper soil profiles, and by senescence and deterioration enrich the soil with small channels, which are essential for infiltration and water storage. They are also responsible for promoting the mass flow of elements essential to plant nutrition.

Table 6 indicates the development of the number of internodes in coffee plants grown with cover crops. Concerning the number of internodes of the plagiotropic branches of the skeletonized coffee, the plants that were managed between the lines and that provided a greater number of internodes were *Crotalaria spectabilis*,

Table 4: Green mass and dry mass of aerial part of cover plants intercropped with coffee

Treatments	Green mass (g m $^{-2}$)	Dry mass (g m $^{-2}$)
Ruziziensi	0.4333 E	0.0966 E
Brizanta	0.5750 D	0.1250 D
Buckwheat	0.7566 C	0.1700 C
Cocktail*	0.9300 B	0.2100 B
Vigna unguiculata	0.733 C	0.2200 B
Cajanus cajan	1.3766 A	0.3066 A
Crotalaria spectabilis	1.4166 A	0.3166 A
CV (%)	**17.34**	**18.72**

*Cocktail (*Vigna unguiculata*, *Crotalaria spectabilis*, *Cajanus cajan* and Buckwheat). ** Means followed by the same letters in column do not differ significantly by the Scott-Knott Test at the 5% probability level.

Table 5: Supply of nutrients accumulated in the dry mass of cover crops grown between the coffee lines per hectare

Treatments	N	P	K	Ca	Mg	S	Cu	Zn	Mn	B
			Kg ha $^{-1}$						g ha $^{-1}$	
Brizantha	69.2 D	7.3 D	67.9 D	31.5 E	8.0 D	4.2 C	4.7 C	6.3 D	38.0 E	7.9 E
Buckwheat	93.3 D	10.3 C	92.9 C	39.2 E	11.2 C	6.0 B	6.7 C	9.0 C	54.4 D	11.3 D
Cocktaill*	134.5 C	12.0 B	107.7B	50.2 C	13.7 B	6.8 B	8.1 B	11.7 B	66.0 C	14.3C
Vigna unguiculata	145.2 C	12.6 B	60.0 D	48.0 D	12.0 C	6.0 B	7.4 B	10.7 B	67.7 C	13.8C
Cajanus cajan	242.1 A	17.8 A	142.2A	67.7 B	16.9 A	8.5 A	10.0 A	15.0 A	96.0 B	19.7B
Crotalaria spectabilis	174.0 B	18.3 A	155.7A	73.9 A	18.3 A	8.7 A	10.9 A	16.4 A	104.9 A	21.5A
Ruziziensis	55.75 D	5.5 D	47.60D	17.8 E	6.04 D	3.1 C	3.1 C	4.0 D	32.0 E	6.0 E
CV (%)	**18.58**	**13.97**	**19.19**	**15.30**	**17.15**	**20.29**	**13.47**	**12.36**	**18.27**	**10.34**

*Cocktail (*Vigna unguiculata*, *Crotalaria spectabilis*, *Cajanus cajan* and Buckwheat). ** Means followed by the same letters in column do not differ significantly by the Scott-Knott Test at the 5% probability level.

cocktail, brizantha and buckwheat, highlighting that all the cover species provided superior results when compared to the control.

These results probably occur due to several factors favorable to plots cultivated with cover crops, such as lower temperatures to which the coffee roots are exposed, higher humidity conservation, nutrient cycling of the deeper layers, among other benefits promoted by the intercrop.

Tables 7 and 8 show the results of soil analysis, in the 0-10cm and 10-20 cm, respectively, after the treatments with the cultivation of cover plants. In regard to the Table 7, the parameters of pH, P, K, Mg, H+Al, T, t, and SB, had no statistical differences between the treatments. However, the control treatment had higher value of organic matter. As for Ca, when Brizantha was used, the content was higher than the others cover crops. Finally, *cajanus cajan* showed better results in terms of aluminum saturation.

Concerning potassium (K), there was a slight decrease in the studied plots, a fact corroborated by Ernani *et al*. (2007), who reports that K^+ presents a characteristic of high mobility in the soil, hardly accumulating in the upper layers of the soil.

In what concerns Table 8, the parameters of P, K, t, SB, V, and m, showed no statistical differences among the cover crops tested. Nevertheless, *C. spectabilis*, buckwheat, the cocktail, and *V. unguiculata* showed a higher pH. For the organic matter, we can highlight the group with Ruziziensis, Brizantha, buckwheat, and *V. unguiculata* as the ones with better results. It is observed that the increase of OM in the soil using cover crops is a fact proven by several authors.

It is also observed that the species Ruziziensis, *V. unguiculata,* and *C. cajan* presented higher contents of Ca. Also, *V. unguiculata* was the cover crop that had better results concerning all the parameters (Table 8).

These data are contrary to the results obtained by Nascente *et al*. (2014), in which working in a no-tillage system, claims that, due to the accumulation of nutrients on the surface and improvement in soil organic matter, there was an increase in soil acidity. Garcia and Rosolem (2010) complement that during the mineralization of soil organic matter, the production of organic acids occurs, contributing to the reduction of soil pH.

Benites *et al*. (2010) mentioned that calcium and magnesium behave in a manner contrary to potassium, not leaching from the straw formed by cover plants, and are independent of the decomposition of biomass, thus accumulating in the soil.

The CTC, the Sum of Bases (SB), and Base saturation as they represent calculations obtained through the exchangeable bases of soil and hydrogen and aluminum (H^+, Al^{3+}), obviously showed favorable differences in their levels. Concerning chemical analysis in the 10-20 cm layer, the results were similar, differing only by the K that showed higher levels due to its leaching facility (Brito *et al*., 2014).

Regarding the phytosociological study, Maciel *et al*. (2010) and Ferreira *et al*. (2011), reported that the importance of phytosociological knowledge of the species considered as spontaneous plants in coffee plantations or any plant community is in the fact that it allows the evaluation of the population present in a certain place, being, therefore, a great tool, which allows elaborating strategies for the management of this group of individuals that can cause damage to the economically exploited crop. With knowledge in phytosociology, coffee growers and technicians will be able to identify which species are the most important in coffee plantations, enabling the use of efficient practices for management through the integration of different methodologies, adequately controlling spontaneous herbs.

Inoue *et al*. (2012), working with pastures, shares the same philosophy, stating that “the phytosociological survey is important for the knowledge of the populations and the biology of the species found, being an important tool to define the management and cultural treatments, whether in implantation, recovery or to conduct pastures”.

Table 6: Average of temperature and soil humidity, and the number of internodes of the plagiotropic branches of coffee

Treatments	Temperature (°C)	Soil humidity (%)	Number of internodes
Control	30.10 A	20.30 D	8.96 D
Ruziziensis	25.33 B	28.53 A	11.43 B
Brizanta	23.70 B	29.70 A	12.30 A
Buckwheat	25.53 B	29.93 A	12.16 A
Cocktail*	24.43 B	29.00 A	12.50 A
Vigna unguiculata	26.23 B	24.50 C	10.20 C
Cajanus cajan	24.93 B	27.13 B	11.63 B
Crotalaria spectabilis	24.76 B	27.13 B	12.73 A
CV (%)	**7.64**	**11.97**	**12.27**

*Cocktail (*Vigna unguiculata*, *Crotalaria spectabilis*, *Cajanus cajan* and Buckwheat). ** Means followed by the same letters in column do not differ significantly by the Scott-Knott Test at the 5% probability level.

Table 7: Nutrient content in the 0-10 cm soil profile at the end of the survey

Treatments	pH	MO	P	K	Ca	Mg	H+ Al	T	t	SB	V	m
	$CaCl_2$	%	mg/dm³		cmol$_c$/dm³						%	
Implantation*	4.85	2.35	5.53	115.5	2.61	0.70	5.56	9.16	5.17	3.60	39.89	16.05 B
Control	5.49 A	2.73 B	8.23 A	81.34A	3.04 A	0.88 A	4.11 A	8.23 A	4.42 A	4.12 A	50.10 A	17.07 B
Ruziziensis	5.63 A	3.22 A	8.45 A	83.48 A	3.12 A	0.90 A	4.22 A	8.46 A	4.53 A	4.23 A	50.07 A	13.13 B
Brizantha	5.32 A	2.94 A	7.98 A	78.84 A	2.94 B	0.85 A	3.99 A	7.99 A	4.28 A	4.09 A	50.10 A	18.23 B
C. spectabilis	5.84A	3.72 A	9.52 A	94.06 A	3.51 A	1.02 A	4.76 A	9.53 A	5.11 A	4.22 A	50.05 A	15.87 B
Buckwheat	5.61A	3.21 A	8.42 A	83.26 A	3.11 A	0.90 A	4.21 A	8.43 A	4.52 A	4.77 A	50.03 A	12.62 B
Cocktail**	5.72 A	3.59 A	8.58 A	84.79 A	3.16 A	0.92 A	4.29 A	8.59 A	4.60 A	4.30 A	50.03 A	7.33 C
Vigna unguiculata	5.41A	3.25 A	8.12 A	80.23 A	2.99 A	0.87 A	4.06 A	8.13 A	4.36 A	4.07A	50.03 A	10.75 C
Cajanus cajan	5.69 A	3.09 A	8.53 A	84.34 A	3.15 A	0.91 A	4.27 A	8.54 A	4.58 A	4.28 A	50.03 A	23.86 A
CV (%)	**3.07**	**9.98**	**5.53**	**5.83**	**6.35**	**5.65**	**11.35**	**13.76**	**5.95**	**5.24**	**6.26**	**14.11**

* Implantation (research installation time. **Cocktail (*Vigna unguiculata*, *Crotalaria spectabilis*, *Cajanus cajan* e Buckwheat). ***Means followed by the same letters in column do not differ significantly by the Scott-Knott Test at the 5% probability level.

Table 8: Nutrient content in the 10-20 cm soil profile at the end of the survey

Treatments	pH	MO	P	K	Ca	Mg	H+ Al	T	t	SB	V	m
	CaCl²	%	mg/dm³		cmolc/dm³						%	
Implantation*	4.81	2.22	5.15	107.37	2.2	1.01	5.11	8.57	5.29	3.46	40.40	33.48
Control	5.33A	2.64 B	10.76 B	102 A	2.63B	0.8B	3.90A	7.69 B	3.79A	3.69 A	48.02A	28.34 A
Ruziziensis	4.90 B	3.00A	18.23 A	112 A	3.40A	0.95B	3.43B	8.06A	4.95A	4.63 A	57.47A	19.45 A
Brizanta	4.80 B	3.05 A	19.05 A	125 A	2.70 B	1.1A	2.80B	6.74 B	4.94A	4.11 A	60.93A	21.07 A
C.spectabilis	5.50A	2.72 B	16.63 A	116 A	2.86 B	0.75B	4.51A	8.72A	4.21A	3.90 A	44.73A	12.73 A
Buckwheat	5.16A	3.10 A	19.20 A	118 A	3.05 B	1.05A	3.73A	8.25A	4.92A	4.40 A	53.3A	27.86 A
Cocktaill**	5.10A	2.43 B	16.56 A	101 A	2.90 B	1.1A	4.30A	8.69A	5.39A	4.25 A	49.0A	12.88 A
Vigna unguiculata	5.36A	3.10 A	19.06 A	121 A	3.66A	1.3A	4.23A	9.50A	5.70A	5.27A	55.4A	14.72 A
Cajanus cajan	4.15 B	2.96 B	18.23 A	112 A	3.43A	1.05A	4.36A	9.20A	5.00A	4.76 A	51.7A	14.98 A
CV (%)	**8.50**	**8.64**	**16.31**	**7.51**	**12.21**	**18.12**	**14.70**	**17.26**	**12.51**	**11.67**	**14.50**	**13.36**

* Implantation (research installation time. **Cocktail (*Vigna unguiculata*, *Crotalaria spectabilis*, *Cajanus cajan* e Buckwheat). ***Means followed by the same letters in column do not differ significantly by the Scott-Knott Test at the 5% probability level.

In this work, a phytosociological survey was initially carried out to identify which plants were in the studied plots and these are shown in Table 9.

According to Table 9, there are six spontaneous plant species present in the studied crop, with *Digitaria insularis* being difficult to control, including resistance to Glyphosate (Powles and Yu, 2010; Carvalho *et al*., 2012; Melo *et al*., 2012 and Reinert *et al*., 2013).

Concerning phytosociological aspects, the focus of the work was relative dominance (DoR), which corresponds to the species' participation (%) related to the total basal area. This parameter is of great importance in phytosociological studies.

Cajanus cajan presented the following results for this parameter: *Ipomoea purpurea* - 12.5; *Conyza bonariensis* - 9.99; *Hairy bidens* - 31.2*; Sonchus oleraceus* - 17.66; Mentha *suaveolens* - 18.66, and *Digitaria insularis* - 9.99 plants per m2, showing great suppression in the *D. insularis*, reducing by half its presence in the studied area. A minor suppression occurred in the *Ipomoea purpurea*, *Emilia sonchifolia*, and *Ageratum conyzoides*, while the indexes were expanded for Bidens pilosa. Regarding *Digitaria insularis*, Concenço *et al*. (2018) mention that, at the beginning of the development, this species presents a lower capacity of competition, being easily suppressed by species that present high size, as *Cajanus cajan*. Picão preto is highly adapTable in the region.

Analyzing the data presented in Table 9, it can be concluded that *C. spectabilis* synthesizes allelopathic substances with a high suppression capacity of *Conyza bonariensis*, preventing its germination and development, a very positive result, considering that this herb is difficult to control, containing biotypes resistant to glyphosate, according to Mendonça *et al*. (2016). However, it was not efficient in controlling the other herbs present.

Vigna unguiculata suppressed the germination of *Digitaria insularis* by 100%, a plant that has been widely distributed in agricultural regions where cover crops are not used in the off-season, according to Correia *et al*. (2010). This spontaneous herb has proliferated due to its ability to adapt to different edaphoclimatic conditions, reduce the development of other species, according to Silveira *et al*. (2018), and its resistance to Glyphosate. Due to its efficiency in controlling the herb, *Vigna unguiculata* proves to be viable for cultivation in problematic areas infested with *Digitaria*, however, concerning the other herbs present, its efficiency was minimal.

The plant cocktail only contributed to the suppression of *Mentha suaveolens*, a plant that is easy to manage in coffee plantations. According to these results, it appears that even using a variety of cover plant species, efficient suppression of all spontaneous plants is not achieved, confirming the great adaptation of these herbs in the region.

Buckwheat population dynamics demonstrated good phytosociological efficiency, reducing the infestation of *Ipomea* sp., *Conyza bonariensis*, and *Digitaria Insularis* and less efficacy in controlling the others. It is interesting to highlight that this cover plant was efficient in reducing the germination of two species considered problematic for regional coffee-growing due to glyphosate resistance, being, therefore, an alternative for areas with a great infestation of these herbs.

In the plots cultivated with *Urochloa brizantha*, in the population dynamics of spontaneous herbs present in the coffee crop, it was found that this cover plant has some efficiency on *Digitaria insularis* and *Ipomea* sp and low efficiency in the control of the other herbs. These results are contrary to the research of several authors who claim that many species of the genus *Brachiaria* have an allelopathic effect on other plants (Oliveira and Brighenti, 2018).

When *Urochloa ruziziensis* is used in the population dynamics of weeds, the result was like *Brizantha*, showing a good efficiency in suppressing bitter and undergrown grass, however, low efficiency for other weeds. Results contrary were found by Castro *et al*. (2011), who state

Table 9: Spontaneous herb population present in the crop at the beginning of the experiment (plant density m^2)

Spontaneous herb	*Ipomoea purpurea*	*Conyza bonariensis*	*Bidens pilosa*	*Sonchus oleraceus*	*Mentha suaveolens*	*Digitaria insularis*
Implantation*	23.75	18.9	15	12.5	11.35	18.5
Control	29.9	14.8	13.5	12.6	10.9	18.3
Cajanus cajan	12.5	9.99	31.2	17.66	18.66	9.99
Crotalaria spectabilis	15.2	0	23.4	33.2	15.7	12.5
Vigna unguiculata	21.2	16.6	23.5	26.5	12.2	0
Cocktaill**	10	18.2	33.7	31.5	0	6.6
Buckwheat	7	8.8	25.4	35	16.6	7.2
Brizanta	12.1	15.7	19.9	20.2	22.2	9.9
Ruziziensis	17.7	11.7	26.6	28.2	7.8	8

* Implantation (research installation time). **Cocktail (*Vigna unguiculata, Crotalaria spectabilis, Cajanus cajan* e Buckwheat).

that “this species has a high capacity for the competition to establish itself in the area and fully cover the soil. The high production of dry matter and efficiency in suppressing weeds”.

CONCLUSIONS

The cover plants analyzed contributed to the improvement of nutrient contents in the soil, maintained a better level of humidity and milder temperatures, providing greater development to the skeletonized coffee tree. They still have a positive influence on weed control, but none has the characteristic of suppressing all the plants presented in the research, requiring knowledge from technicians and coffee growers of the weed species in the crops in order to be able to use cover plants that are efficient in the management of Skeletal coffee

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REFERENCES

Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM & Sparovek G (2013) Köppen’s climate classification map for Brazil. Meteorologische Zeitschrift, 22:711-728.

Balota EL, Calegari A, Nakatani AS & Coyne MS (2014) Benefits of winter cover crops and no-tillage for microbial parameters in a Brazilian Oxisol: A long-term study. Agriculture, Ecosystems and Environment, 197:31-40.

Benites VM, Resende AV, Carvalho MCS, Polidoro JC, Bernardi ACC & Oliveira FA, (2010) Potassim, calcium and magnesium in Brazilian agriculture. In: Prochnow LI (Ed.) Boas práticas para uso eficiente de fertilizantes. Canadá, IPNI. p.100-130.

Brito OR, Telles TS, Schnitzer JA, Gaspar GG & Guimarães MF (2014) Mobilidade do potássio no solo em função de diferentes tipos e doses de resíduos vegetais. Semina: Ciências Agrárias, 35:3043-3051.

Cardoso RA, Bento AS, Moreski HM & Gasparoto F (2014) Influência da adubação verde nas propriedades físicas e biológicas do solo e na produtividade da cultura de soja. Semina: Ciências Biológicas e da Saúde, 35:51-60.

Carvalho LB, Alves PL, González-Torralva F, Cruzhipolito HE, Rojano-Delgado AM, Prado R, Gilhumanes J, Barro F & Castro MD (2012) Pool of resistance mechanisms to glyphosate Digitaria insularis. Journal of Agricultural and Food Chemistry, 60:615-622.

Castro GSA, Crusciol CAC, Negrisoli E & Perim L (2011) Sistemas de produção de grãos e incidência de plantas daninhas. Planta Daninha, 9:1001-1010.

Colodetti TV, Tomaz MA, Rodrigues WN, Verdin Filho AC, Cavatte PC & Reis EF (2018) Arquitetura da copa do cafeeiro arábica conduzido com diferentes números de ramos ortotrópicos. Revista Ceres, 65:415-423.

Concenço G, Ito MA, Marques RF, Melo TS, Silva LB & Linhares LT (2018) Trigo como supressor de infestação de capim-amargoso. Dourados, Embrapa. 7p. (Comunicado Técnico, 234).

Correia NM, Leite GJ & Garcia LD (2010) Resposta de Diferentes Populações de Digitaria insularis ao Herbicida Glyphosate. Planta Daninha, 28:769-776.

Costa MJN, Pasqualli RM & Prevedello R (2014) Efeito do teor de matéria orgânica do solo, cultura de cobertura e sistema de plantio no controle de *Pratylenchus brachyurus* em soja. Summa Phytopathologica, 40:63-70.

Ernani PR, Bayer C, Almeida JÁ & Cassol PC (2007) Mobilidade vertical de cátions influenciada pelo método de aplicação de cloreto de potássio em solos com carga variável. Revista Brasileira de Ciência do Solo, 31:01-09.

Embrapa - Empresa Brasileira de Pesquisa Agropecuária (2011) Manual de métodos de análise do solo. 2nd ed. Rio de Janeiro, Centro Nacional de Pesquisas de Solos. 230p.

Ferreira EA, França AC, Carvalho RF, Santos JB, Silva DV & Santos EA (2011) Avaliação fitossociológica da comunidade infestante em áreas de transição para o café orgânico. Planta Daninha, 29:565-576.

Ferreira DF (2014) Sisvar: a guide for its bootstrap procedures in multiple comparisons. Ciência e Agrotecnologia, 38:109-112.

Garcia RA & Rosolem CA (2010) Aggregates in a Rhodic Ferralsol under no-tillage and crop rotation. Pesquisa Agropecuária Brasileira, 45:1489-1498.

Gemelli A, Oliveira Junior RS, Constantin J, Braz GBP, Jumes TMC, Oliveira Neto AM, Dan HA & Biffe DF (2012) Aspectos da biologia de *Digitaria insularis* resistente ao glyphosate e implicações para o seu controle. Revista Brasileira de Herbicidas, 11:231-240.

Inoue MH, Perreira KM, Santana DC, Conciani PA & Sztoltz CL (2012) Levantamento fitossociológico em pastagens. Planta Daninha, 30:55-63.

Japiassú LB, Garcia ALA, Guimarães RJ, Padilha L & Carvalho CHS (2010) Ciclos de poda e adubação nitrogenada em lavouras cafeeiras conduzidas no sistema “safra zero”. Coffee Science, 5:28-37.

Maciel CDG, Poletine JP, Neto AMO, Guerra N & Justiniano W (2010) Levantamento fitossociológico de plantas daninhas em cafezal orgânico. Bragantia, 69:631-636.

Maluf HJGM, Soares BEM, Silva IR, Neves JCL & Silva LOG (2015) Decomposição de resíduos de culturas e mineralização de nutrientes em solo com diferentes texturas. Revista Brasileira de Ciência do Solo, 39:1681-1689.

Marcante NC, Prado RM, Camacho MA, Rosset JS, Ecco M & Savan AL (2010) Determinação da matéria seca e de teores de macronutrientes em folhas de frutíferas usando diferentes métodos de secagem. Ciência Rural, 40:2398-2401.

Melo MSC, Elache RL, Grossi BCAC, Nicolai M & Christoffoleti PJ (2012) Alternativas de controle químico para capim-amargoso (*Digitaria insularis*) resistente ao glifosato. Revista Brasileira de Herbicidas, 11:195-203.

Mendonça KDR, Vieira BS & Sousa LA (2016) Controle em pós-emergência de *Conyza canadensis* e *Conyza bonariensis* com extratos de *Carnavalia ensiformis*. Ciência Agrícola, 14:51-58.

Moreira CF, Diniz CCV & Paiva AO (2016) Manejo sustentável do cafeeiro. Machado, Associação de cafeicultura orgânica do Brasil. 42p.

Nascente AS, Silveira PMM, Lobo Junior M, Santos GG & Cunha PCR (2014) Atributos químicos de latossolo sob plantio direto afetados pelo manejo do solo e rotação de culturas. Revista Caatinga, 1:153-163.

Oliveira MF & Brighenti AM (2018) Controle de plantas daninhas: métodos físico, mecânico, cultural, biológico e alelopatia. Brasília, Embrapa. 198p.

Partelli FL, Vieira HD, Freitas SP & Espondola JAA (2010) Aspectos fitossociológicos e manejo de plantas espontâneas utilizando espécies de cobertura em cafeeiro conilon orgânico. Semina: Ciências Agrárias, 31:605-618.

Pitelli RA (2000) Estudos fitossociológicos em comunidades infestantes de agroecossistemas. Jornal Conserb, 1:1-7.

Powles SB & Yu Q (2010) Evolution in action: plants resistant to herbicides. Annual Review of Plant Biology, 61:317-347.

Pereira SP, Baliza DP, Santos MO, Alves JD & Guimarães RJ (2013) Influência do espaçamento de cultivo em duas épocas de poda nos teores caulinares de carboidratos em cafeeiros. Coffee Science, 8:460-468.

Presotto RA, Silva SD, Marota HB, Moreira RC, Pereira MG & Zonta E (2014) Mineralização da torta produzida diretamente da semente (pds) de mamona. Revista Caatinga, 27:24-30.

Ragassi CF, Pedrosa AW & Favarin JL (2013) Aspectos positivos e riscos no consórcio cafeeiro e braquiária. Visão Agrícola, 1:29-32.

Reinert SC, Prado ABCA & Christoffoleti PJ (2013) Curvas de dose-resposta comparativas entre os biótipos resistente e suscetível de capim-amargoso ao herbicida glyphosate. Revista Brasileira de Herbicidas, 12:260-267.

Rufini M, Silva MAP, Ferreira PAA, Cassetari AS, Soares BL, Andrade MJB & Moreira FMS (2014) Symbiotic efficiency and identification of rhizobia that nodulate cowpea in a Rhodic Eutrudox. Biology and Fertility of Soils, 50:115 122.

Santos FS, Zanão Junior LA, Secco D, Dias PP, Tomassoni F (2014) A utilização de plantas de cobertura na recuperação de solos compactados. Acta Iguazu, 3:82-91.

Silveira HM, Langaro AC, Cruz RA, Sediyama T & Silva AA (2018) Gyphosate efficacy on sourgrass biotypes with suspected resistance collected on GR-crop fields. Acta Scientiarum Agronomy, 40:69-74.

Scarpare Filho JA (2013) Poda de frutíferas. Revista Brasileira de Fruticultura, 35: https://doi.org/10.1590/S0100-29452013000300001.

Thomaziello RA (2013) Uso da poda no cafeeiro: por que, quando e tipos utilizados. Visão Agrícola, 1:1-4.