Journal of Agriculture and Environmental Sciences
June 2016, Vol. 5, No. 1, pp. 91-100
ISSN: 2334-2404 (Print), 2334-2412 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jaes.v5n1a10
URL: https://doi.org/10.15640/jaes.v5n1a10

Herbaceous Legumes Intercropping in Weed Management of the Coffee Crop

Julio C. F. Santos[1], Aquiles J. da Cunha[2], Francisco A. Ferreira[3], Ricardo H. S. Santos[3], Ney S. Sakiyama[3] & Paulo C. de Lima[4]

Abstract

This study aimed to determine the influence of herbaceous legumes on weeds and on coffee culture. The experiment was set in a Catuaí coffee crop with 3 x 1 m spacing. It was used a random block with four replicates, consisting of eight treatments in a 3 x 2 + 2 factorial scheme, with three legume species: forage peanut (*Arachis pintoi*), siratro (*Macroptilium atropurpureum*) and lablab (*Dolichos lablab*) and two different planting forms in the crop inter-rows with two and three rows of legumes spaced by 0.50 and 0.25 m, respectively. The additional treatments were hand weeding with hoe and chemical control with glyphosate. The legume lablab at 90 and 120 days after planting provided the greatest soil cover, the greatest predominance of its vegetation on the weeds and lower weed infestation. The reduction of the density and biomass of the weeds was promoted in the first year by lablab and siratro in the dry season and no differences between them in the rainy period, and in the second year promoted by forage peanut. Among the legumes species and among the additional treatments there were effects in the productivity of the coffee only in the last harvest.

Keywords: Soil cover, Green manuring, Intercropping cultivation, Arachis pintoi, Macroptilium atropurpureum, Dolichos lablab.

1. Introduction

The adaptation of the coffee growing to the current market demands has been requesting innovation of the production system. Among the main demands, they are the use of good agricultural practices that it prioritizes the reduction of industrialized inputs and the conservation of the environmental resources. The weed management of the coffee crop without criteria has caused negative impacts. The main attention is to weed management conducted almost exclusively through chemical control. The inappropriate and excessive use of post-emergent herbicides can cause injuries to the coffee, and the pre-emergent soil crusting contribute to causing surface erosion and lack of vegetation cover that promotes the reduction of organic matter (Alcântara et al., 2007, 2009). Also, the excessive mechanical control may favor the survival of weed to leave alive their roots and impair the quality of the soil to form thickened layer and decrease the aggregate stability (Alcântara and Ferreira, 2000a).

In the conventional coffee production, the most common forms used in weed control are the hand weeding with hoe practices, and slashed manual and mechanized. However, the ecological basis of the coffee weed management is characterized by the use of chemical control limitation, implying the search for alternatives considering the age, development and spacing of the crop.

[1]Dsc., Researcher, Brazilian Agricultural Research Corporation-Embrapa, Embrapa Café-Embrapa Building, Final Av. W/3 Norte, 70.770-901, Brasília, DF, Brazil. julio.cesar@embrapa.br
[2]Dsc., Prof., Agronomy, Academical Center of the Cerrado-Patrocínio-Unicerp, Av. Liria Terezinha Lassi Capuano, 466 - Chácara das Rosas, 38.740-000, Patrocínio,MG, Brazil. aquiles@unicerp.edu.br
[3]Dsc., Prof., Agronomy, Department of Crop Science, Federal University Viçosa-UFV, Av. P.H. Rolfs, s/n, 36.570-000, Viçosa, MG, Brazil; ftc@ufv.br
[4]Dsc., Researcher, Minas Gerais Agricultural Research Corporation-Epamig-Campus of Federal University Viçosa-UFV, Vila Gianetti, 36.571-000, Viçosa, MG, Brazil. plima@epamig.ufv.br

An alternative is the integrated management of weeds by growing cover crops between rows of culture, which will promote the reduction of weed infestation, although possible interference may occur in the main crop (Williams et al., 1998). Soil cover plants with herbaceous legumes can be intercropped with perennial crops (Perin et al., 2000; Perin et al., 2002; Cunha and Alvarenga, 2003), providing soil cover and weed suppression with reduced environmental impacts and control costs. The vegetation or residue cover crops interfere with germination, emergence and growth of weeds by physical effect of competition or the chemical effect of allelopathy (Bond and Grundy, 2001; Hatcher and Melander, 2003).

The use of legumes in weed management depends on its ability to adapt, persistence and management, uniformity in establishing and soil cover, biomass production, weed suppression and less interference in the main crop (Perin et al., 2000; Severino and Christoffoleti, 2004).

2. Objectives

This study aimed to evaluate the influence of consortium of herbaceous legumes on the infestation and the development of weeds and of coffee crop.

3. Materials and Methods

The work was carried out from December 2007 to July 2010, in a coffee plantation Catuaí Red (CH 2077-2-5-99), planted in 1989 and pruned in 1998, located at 20º 45' S and 42º 51' O, to 693 m of altitude, in the region of Zona da Mata, in Viçosa, Minas Gerais. The soil was classified as Oxisol dystrophic clayey in land with southern exposure of face and mountainous with 40% slope.

The experiment consisted of eight treatments, applied centrally in the two lines of coffee, in a factorial 3 x 2 + 2, with three herbaceous legumes: forage peanut (*Arachis pintoi*), siratro (*Macroptilium atropurpureum*) and lablab (*Dolichos lablab*) and two forms of planting with two and three rows of legumes spaced pulses 0.50 and 0.25 m, respectively. The two additional treatments were hand weeding with hoe and chemical control with glyphosate. The experimental design was a randomized block with four replications, totaling 32 plots of three rows of seven coffee plants with spacing of 3 x 1 m, useful being the five central plants.

The planting forage peanut was performed by stolons 20 cm rooted in advance raised for 30 days and then inoculated by dipping the roots in a diluted solution of Rhizobium inoculant Semia 6439 (Bradyrhizobium japonicum) at a ratio of 250 g to 20 U of water. Planting density was 10 stolons per meter, using the two lines of parcels with two and three rows of 5 m, respectively, 280 and 420 stolons.

The seeding siratro and lablab was preceded by inoculation of seeds in homogeneous paste consisting of 250 g of Rhizobium inoculant in 400 ml of water, respectively Semia 656 (Bradyrhizobium.) and Semia 662 (Bradyrhizobium elkanii). The seeding rate of siratro and lablab was respectively 40 and 20 seeds per meter, requiring the two lines of the plots with two and three rows of 5 m the respective amounts of 15 and 22.5 g of siratro seeds and 120 and 180 g of lablab seeds.

The additional treatment of chemical control consisted of glyphosate 360 g L^{-1} at a dose of 720 g/ha or 2 L/ha of commercial product. For application, was used knapsack sprayer 20 L-tipped TTI 11002 spray, a pressure of 2 KGF and volume of 150 L/ha, whose sprays were in the months of June, September, December and March. The additional treatment of hand weeding with hoe between the lines was also performed in these months. In the coffee lines were performed for cleaning hand weeding the range of 0.80 m on each side of the coffee, which delimits the growth of legumes and pruning. In the first two months, there were two hand weeding on all parcels to favor the establishment of legumes.

The ground lime based on the analysis, and dolomitic limestone and 80% PRNT dosage 150 g/plant applied only once in all plots. The chemical fertilization of coverage based on soil analysis was split in October, December, February and April, using the NPK 20-05-20 formulation at a dose of 100 g/plant per application in all plots.

In conducting the experiment, as the crop conditions was effect up the thinning practices, pruning and phytosanitary control of the coffee in all plots, followed by production techniques (MATIELLO et al., 2005). The collection of climate data of rainfall and maximum and minimum temperatures (Figure 1) was held as daily record on Automated Weather Station located near the experimental area. In the dry period of two years was measured soil moisture of soil samples collected at a depth of 0-20 cm in the center of the lines of the plot.

The samples were placed in sealed impermeable packaging for drying in an oven at 110 °C for 24 hours, yielding the mass of water and soil solids for gravimetric determination of moisture (Embrapa, 1997).

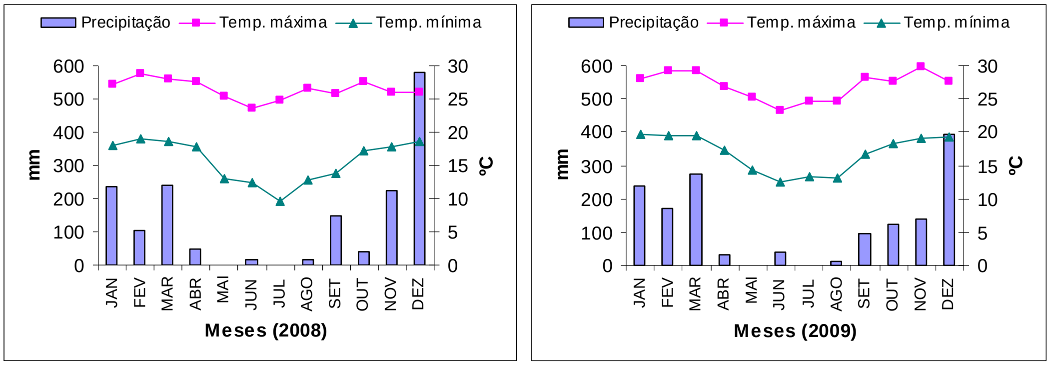

Figure 1. Rainfalls and monthly averages of maximum and minimum temperatures of the coffee crop in production intercropped with herbaceous legumes, Viçosa, MG, 2008 and 2009.

The soil cover by legume, the predominance of legume vegetation on weeds and weed infestation were recorded in percentage at 90 and 120 days after planting (DAP). These evaluations were based on the use of the method of the same square grid, formed by the perpendicular intersection of two strings stretched in a wooden frame, described by Favero et al., (2001). This method was adapted, using the center of each leading portion, a rectangular plastic net 1 x 6 m, with a distribution of 100 square hollow of 20 cm side and spaced 4 cm apart. The percentage of the soil cover by legume resulted from counting squares on vegetation legume with and without the presence of weeds. The percentage of predominance of legume vegetation on weeds was the sum of the squares of soil cover area by the legume without the presence of weeds. The percentage of weed infestations resulted from squares count on all the weeds that were in and out of coverage by legume.

The biomass of the legume was evaluated in May and December of two years by studying the sampling methodology of the population of weeds (Bradshaw and Lanini, 1995). For withdrawing and weighing a sample of 0.5 m^2 legume, used a wooden frame of 0.25 m^2, released randomly in the two inter-rows of the plot. The sample was dried in an oven with forced air at 65 ° C for 72 hours and weighed on an electronic scale to determine the legume biomass productivity, less the area of 60% of the coffee plant.

The density and weed biomass were evaluated every two months in the 2008/2009 and 2009/2010 seasons, the months of May and July of the dry season and in the months of September, November, January and March the rainy season, applying the population survey methodology weed (Bradshaw and Lanini, 1995). The sampling system used a wooden framework of 0.25 m^2, released once every leading, collecting 0.50 m^2 per sample portion. In this framework, the weeds were cut close to the ground and then quantified to determine the density. These plants were placed in paper bags, and placed in a forced circulation air oven at 65 °C for 72 hours for drying and subsequent weighing electronic precision balance for determining the biomass.

The coffee harvest was through manual seed dropping in cloth production soon then transported to the drying yard to reach the 12% moisture content (Matiello et al., 2005). The coffee yield was measured in liters of fruits harvested being removed a 5 kg sample for drying and subsequent determination of processed coffee productivity.

In the statistical analysis we used the Assistat program (Silva and Azevedo, 2002), which contrast involving the means of additional treatments and legumes was compared by F test analysis of variance at 5% probability. The averages of the factors legumes and lines were compared by Tukey test at 5% probability. The data density and weed biomass were transformed into $(x + 0.5)^{1/2}$ for normalization of their distribution in analyzes.

4. Results and discussion

In the overall assessment there was no interaction of legumes with both forms of planting lines. The cultivation of two or three rows of legumes did not influence variables (Tables 1, 3, 4, 6, 7 and 8).

These results are similar in part to Perin et al. (2003), to find that the soil cover and biomass production forage peanut were not affected by these spacing between the rows planting.

The forage peanut and lablab at 90 and 120 Days After Planting (DAP) promoted higher soil cover in the establishment phase. However the lablab provided greater predominance of vegetation on weeds and less infestation of these species (Table 1). This lower weed infestation by lablab, corroborates with the results obtained by Moreira et al. (2009) in the evaluation of influence of the legumes species and of the management period on the weed coffee plants, wherein the lablab four months influenced in the lower infestation of these species.

Table 1. Soil cover (%) and vegetation predominance (%) of legumes in intercropping with coffee production at 90 and 120 DAP upon weed infestation (%), Viçosa, MG, March and April, 2008.

Treatments	Cover (%)		Predominance (%)		Infestation (%)	
	90 DAP	120 DAP	90 DAP	120 DAP	90 DAP	120 DAP
Legume						
F.peanut	78,0 a	86,9 a	51,1 b	55,8 b	40,0 a	44,8 a
Siratro	64,1 b	72,4 b	54,0 b	67,6 b	23,3 b	14,8 b
Lablabe	85,0 a	92,5 a	81,8 a	90,9 a	6,9 c	3,8 c
DMS	13,4	14,1	13,5	15,1	9,9	9,7
Row						
Two	73,1 a	84,9 a	60,8 a	72,8 a	23,1 a	21,2 a
Three	78,3 a	82,9 a	63,8 a	70,0 a	23,7 a	21,0 a
DMS	9,0	9,5	9,1	10,2	6,7	6,6
C.V. (%)	16,41	15,42	19,66	18,95	30,98	30,40

Means followed by different letters within each factor in column differ by Tukey test at 5% probability.

The result promoted by forage peanut in soil cover resembles those obtained by Bradshaw et al. (1995), which recorded the full soil cover at 90 days after planting this legume and with the results of Perin et al. (2000), who obtained the maximum soil cover at 120 days. The lablab, which also provided greater soil cover in this period, showed results similar to those achieved by Alvarenga et al. (1995). In establishing the perennial legumes, growth rates are slow in the initial phase, when compared to the annual legumes (Perin et al., 2000), requiring weed control to its full establishment, although in this experiment the forage peanut legume has submitted the advantage of having been planted by stolons. Among the perennial legumes, there was more soil cover by forage peanut than siratro at 90 and 120 DAP, which are shown with same accuracy of results obtained by Dalcomo et al. (1999) in the assessment of the coverage of these legumes in production citrus orchard.

The herbaceous legume intercropping with coffee plants at 90 and 120 DAP allowed the reduction of weed infestation compared to additional treatments hand weeding and chemical control (Table 2). However when comparing between the additional treatments in both periods, it was found that hand weeding allowed greater weed infestation than the chemical control.

Table 2: Influence contrast between legume plants and additional treatments and among additional treatments upon the weed infestation at 90 and 120 DAP in the intercropping of legumes with coffee production, Viçosa, MG, March and April, 2008.

Treatments	Weeds Infestation (%)	
	90 DAP	120 DAP
Additional	31,6*	38,5*
Legume	23,4	21,1
Hand weeding	38,0*	45,0*
Chemical control	25,3	32,0

* Significant contrast by the F test at 5% of probability.

The maintenance of soil cover and the predominance of legume vegetation upon weeds influence in the inhibition of infestation of these plants. These results corroborate those achieved by Bradshaw and Lanini (1995), Leonidas et al. (2000) and Cunha and Alvarenga (2003) that, when comparing the effect of legumes with hand weeding and chemical control, found that these species had the greatest inhibition upon the coffee weed. Also in the use of herbaceous legumes as green manure in other cultures, there was the potential interference of these species in reducing weed populations (Severino and Christoffoleti, 2001; Erasmo et al., 2004; Monquero et al, 2009).

The lablab in the first year and the forage peanut in the second year showed higher biomass production (Table 3), less the area of 60% occupied by coffee plants, for calculating their productivity. The largest biomass of lablab in the first year is justified because it is a legume fast and voluble growth. However, this species showed lower resistance to the dry season, whose characteristic of climbing plant was stimulated by coffee plant shading, causing blanching plants and jeopardizing the regrowth and the biomass in the following year.

Table 3: Biomass of legumes plants (kg / ha) intercropped for two years with coffee crop, Viçosa, MG, 2008 and 2009.

Treatments	Biomass (kg / ha) – Ano 2008	Biomass (kg / ha) – Ano 2009
Legume		
F.peanut	456,64 b	1543,58 a
Siratro	598,46 b	1057,76 b
Lablabe	1250,04 a	270,63 c
DMS	352,48	289,88
Row		
Two	758,91 a	956,60 a
Three	777,85 a	958,05 a
DMS	236,04	194,12
C. V. (%)	35,30	23,30

Means followed by different letters within each factor in the column differ from one another by the Tukey test at 5% of probability.

Although the forage peanut and the siratro present initially slow establishment, they have prostrate growth with better distribution of their branches and leaves together to the soil surface. In the first year, it is expected that the biomass production of these species is low, according to Soares et al. (2006) and Matos et al. (2008). However, having greater resistance to dry period and greater capacity for regrowth, this implies in the trend higher biomass production the following year. Similar results were obtained by Perin et al. (2003) and Andrade et al. (2004) in assessing the growth of tropical legumes, whose forage peanut had more shade tolerance, increased vegetation cover capacity and greater production of biomass, both in the dry season and in rainy.

The density and weed biomass in the dry period of two years, suffered similar influences of legumes compared to additional treatments. However, in the rainy season of the first year the legumes caused greater reduction in density and weed biomass, while the opposite occurred in the second year, whose additional treatments had the greatest influence (Table 4). Among the additional treatments, there were no significant differences in most of the comparisons.

Table 4: Density and Biomass of weeds in the dry and rainy period in the intercropping of coffee crop with herbaceous legumes for two years, Viçosa, MG, 2008/2009 and 2009/2010.

Treatments	First year 2008/2009		Second year 2009/2010	
	Dry period	Rainy period	Dry period	Rainy period
Contrasts[1]		**Density (plants/m²)**		
Additional	3,20	5,84	2,46 ns	3,05*
Legumes	2,76 ns	4,29*	3,99	4,23
Hand weeding	3,54	6,45	3,97	3,76
Chemical control	2,86 ns	5,24 ns	0,95*	2,34 ns
Legumes[2]				
F.peanut	4,47 a	4,66 a	2,76 b	2,51 b
Siratro	2,55 b	4,44 a	4,51 a	4,66 a
Lablabe	1,27 b	3,77 a	4,70 a	5,53 a
DMS	1,37	1,36	1,69	1,34
Row[2]				
Two	3,01 a	4,49 a	4,01 a	4,28 a
Three	3,11 a	4,12 a	4,16 a	4,55 a
DMS	0,92	0,91	1,14	0,90
CV (%)	40,19	23,79	39,37	28,14
Contrasts[1]		**Biomass (g/m²)**		
Additional	2,45 ns	8,49	2,70 ns	3,14*
Legumes	3,00	5,76*	4,71	4,83
Hand weeding	3,31 ns	9,26 ns	4,33 ns	3,93 ns
Chemical control	1,59	7,72	1,07	2,36
		Legumes[2]		
F.peanut	5,21 a	5,90 a	3,25 b	2,44 b
Siratro	2,73 b	6,02 a	4,91 ab	5,41 a
Lablabe	1,07 c	5,37 a	5,97 a	6,63 a
DMS	1,63	2,18	2,16	1,73
		Row[2]		
Two	3,31 a	6,05 a	4,88 a	5,05 a
Three	3,58 a	5,48 a	4,80 a	5,23 a
DMS	1,10	1,47	1,46	1,16
C. V. (%)	49,54	27,64	43,36	32,41

[1] Analysis of contrast: * = significant; and ns = non-significant by the F test at 5% of probability.

[2] Means followed by the same letter in the column do not differ from one another by the Tukey test at 5% of probability.

The forage peanut in the first year, allowed higher density and higher biomass of weeds, especially in the dry season, while in the second year this legume was superior to others in reducing infestation and weed biomass in both periods. The influence of forage peanut in the second year, reducing the density and weed biomass was also observed by Bradshaw et al. (1995) in two years of cultivation this legume with coffee, in which it suppressed weeds satisfactorily, being equal to or better than the herbicide control and brushcutter, showing potential as an alternative in the weeds management, compared with traditional practices.

According Severino and Christoffoleti (2001, 2004), the cultivation of forage peanut as soil cover and managed with cutting your biomass deposited or incorporated into the soil surface showed potential to reduce the level of weeds infestation. Even Leônidas et al. (2000), in the forage peanut consortium with Robusta coffee in a middle ground of high fertility in Rondônia, this legume promoted the reduction of weeds and weeding practices hoeing. The lablab and siratro have provided lower density and biomass of weeds in the first year, allowing the reverse in the second year, in both dry and rainy seasons. The smaller influence of lablab to inhibit weeds in the second year was also observed by Favero et al. (2001).

This result can be attributed to the fact that legume in the second year have presented smaller leaf area, lower production of biomass and lower soil cover rate, implying thereby decrease the potential to reduce weed infestations.

The assessment of soil moisture during the dry period of two years revealed that the lugumes caused higher moisture content compared to additional treatments (Table 5), matching the results of Perin et al. (2000, 2004) to use legumes as a cover crop on the effect of soil moisture. Among the additional control treatments with hoe and herbicide, there was no difference in soil moisture.

Table 5: Soil moisture of the coffee crop by influence of the intercropping with legumes, Viçosa, MG, 2008 and 2009.

Treatments	Soil moisture (%)					
	2008			2009		
	July	August	September	July	August	September
Contrasts[1]						
Additional	15,96	16,94	16,69	15,66	18,41	16,36
Legumes	19,96*	18,14*	19,07*	18,63*	20,60*	17,79*
Hand weeding	16,10^{ns}	17,00^{ns}	17,45^{ns}	16,37^{ns}	19,12^{ns}	16,50^{ns}
Chemical control	15,82	16,87	15,92	14,95	17,70	16,22
Legumes[2]						
F.peanut	18,88a	17,77 a	18,98 a	17,97 a	21,07 a	17,88 a
Siratro	20,61^{a}	18,37 a	19,16 a	19,01 a	20,12 a	17,75 a
Lablab	20,37a	18,26 a	19,06 a	18,91 a	20,62 a	17,72 a
DMS	2,17	1,73	2,29	2,74	3,08	1,84
Rows[2]						
Two	20,67 a	17,78 a	19,44 a	18,53 a	19,85 a	17,38 a
Three	19,24 a	18,49 a	18,70 a	18,73 a	21,35 a	18,19 a
DMS	1,46	1,16	1,54	1,84	2,07	1,24
C. V. (%)	9,10	7,72	9,83	12,16	12,21	8,39

[1] Analysis of contrast, * = significant and ^{ns} = non-significant by the F test at 5% of probability.

[2] Means followed by the same letter in the column do not differ from one another by the Tukey test at 5% of probability.

The cultivation of two or three rows of legumes did not affect the soil moisture. Among the legume species, also there was no significant influence, and these results differ from those obtained in research Perin et al. (2002, 2004), which recorded lower soil moisture content by the forage peanut against the siratro, perhaps because the forage peanut have high production of roots in the soil surface layers, causing more reduction in soil moisture. Also there were differences with forage peanut in the consortium works with perennial crops, conducted by Perin et al. (2003) and Fidalski et al. (2006), which proved more requirement this legume by water, causing the execution of proper management, is essential in prolonged drought conditions.

The coffee crop under cultivation of legumes showed productivity similar to the additional treatments, except in the 2009/2010 harvest most influential of legumes (Table 6). This was partly because the legumes liven up the thermal and hydro variations of soil whose moisture content in the dry season was greater than the additional treatments. However, the weeds control method of can influence the performance of coffee plants (Alcântara et al., 2007, 2009), as the cultivation of herbaceous legume that has potential to increase soil fertility and crop production (Perin et al., 2000, 2002).

Table 6: Yield of processed coffee of coffee crop intercropped with legume, Viçosa, MG, harvest 2007/2008, 2008/2009 and 2009/2010.

Treatments	Yield (bag of 60 kg/ha)		
	2007/2008	2008/2009	2009/2010
Contrasts[1]			
Additional	43,23 ns	19,95 ns	62,13
Legumes	46,38	21,70	66,27 *
Hand weeding	46,20 ns	18,20 ns	64,05 ns
Chemical control	40,25	21,70	60,20
Legume[2]			
F.peanut	42,70 a	21,52 a	66,15 a
Siratro	47,07 a	22,75 a	65,45 a
Lablabe	46,72 a	20,82 a	67,20 a
DMS	13,97	4,55	4,19
Row[2]			
Two	46,20 a	21,58 a	64,87 a
Three	46,55 a	21,81 a	67,81 a
DMS	9,41	3,00	2,82
C. V. (%)	24,32	16,62	5,09

[1] Analysis of contrast, * = significant and ns = non-significant by the F test at 5% of probability.

[2] Means followed by the same letter in the column do not differ from one another by the Tukey test at 5% of probability.

Legumes contribute to fixing nitrogen in the soil, increases in levels of potassium, carbon and organic matter, and greater capacity for cations exchange, allowing an increase in coffee production. Alcântara and Ferreira (2000b) reported that although the type of management in coffee crop inter-rows cause effects on soil properties, the difference in crop productivity appears after several harvests, provided that they continue the lines of coffee plants with free tracks weed.

The coffee productivity did not differ by the influence of the species of legumes with the production biannuality performing normal. Among the additional treatments, productivity did not differ, matching the results of Toledo et al. (1996) compared the frequency of hand weeding with chemical control in 12 coffee crop harvests.

5. Conclusions

The legume lablab at 90 and 120 days after planting provided greater soil cover, greater predominance of vegetation on the weed and less weed infestation in the coffee plantation. The reduction of the density and biomass of the weeds was promoted in the first year for lablab and the siratro in the dry season and no differences between them in the rainy season, and in the second year promoted by forage peanut. The cultivation of two or three rows of herbaceous legumes in the inter-rows of coffee plants did not influence legumes, weeds and coffee crop.

Among the species of legumes and among additional treatments, there was no effect of difference in soil moisture and coffee productivity except in the last harvest.

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