Soil Cover and Weed Control on Coffee Intercropping Perennial Legume

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Abstract

The legumes are favorite species in green manure and, depending on the management, they can promote good soil coverage between the rows on the coffee plantation and reduce the weed infestation. This study evaluated soil coverage and weed infestation on the producing coffee management with forage peanut and perennial soybean. The experiment was done in Patrocínio, MG, in a 11 years old producing coffee orchard, cultivar Catuaí Vermelho IAC-99, spaced by 3.80 x 0.70 m. Nine treatments were evaluated as a 2^3+1 factorial, in randomized blocks, with 4 repetitions, with two perennial legumes: forage peanut (Arachis pintoi) and perennial soybean (Glycine wightii); two types of side management: without side management, or with side management with glyphosate at 50 cm from canopy projection; two types of vertical management: without vertical management, or with legume vertical management at 5 cm above soil level. The additional treatment was done with the herbicide glyphosate (1.0 kg ha^{-1} of acid equivalent) between the rows. Intercropping forage peanut and perennial soybean in all management provided good soil cover, reducing the weed infestation. The forage peanut with side and vertical management and perennial soybean presented smaller weed infestation. There was a negative and significant correlation among legume soil cover and weed infestation.

Keywords: green manure; *Coffea Arabica; Arachis pintoi; Glycine wighti*

Introduction

A new coffee growing model based on sustainable management practices has been waking up the interest on the part of the farmers in the last years, especially in the Minas Gerais' Cerrado region. The requirement for traceability of certified coffees and aggregation of value to the marketed product reflect a new scenery in the Brazilian coffee growing, in which should be prioritized the reduction of industrialized inputs and the conservation of the environmental resources.

Sustainability practices also apply in weed management in influencing environmental quality and crop yield. Weeds of coffee plantations controlled efficiency and rationality without cause negative interference in the development, growth and yield of crops (Ronchi & Silva 2006), as well as some control methods can cause damage to crops, resulting from its misuse and incorrect. Moreover, conventional and repetitive methods of weed control compromise the sustainability of the coffee, causing detrimental impacts to agriculture and render assistance to the compliances by certification programs of production and product in evidence in the Cerrado region of Minas Gerais (Santos et al. 2008).

The practice of covering and protection of the soil surface in weed management in coffee prevent the formation of surface compacted layers and the occurrence of erosion. They also improve soil fertility, with the supply of organic matter and nutrients resulting from vegetation management (Alcantara et al. 2009).

The cultivation of annual or perennial legumes in agricultural systems, in addition to serving as a green manure, may have the purpose of reducing weed infestations (Favero et al. 2001). These species should be able to withstand water stress during winter (Pacheco et al. 2008), with the advantage to sprout after cutting and maintaining ground cover permanently, unlike the annual legumes that need to be replanted every year (Espindola et al. 2006). These green manures can be managed with herbicide or hand and mechanical method result in the accumulation of layers of straw left on the soil surface.

Several legumes species suitable for the practice of green manuring, can be planted between the rows of coffee farming as velvet bean dwarf (*Stizolobium sp*), labe-labe (*Dolichos lablab*), crotaloaria (*Crotalaria spectabilis*), forage peanut (*Arachis pintoi*), leucaena (*Leucaena leucocephalla*), cassia (*Cassia mangeum*) and velvet bean (*Stilozobium aterrimum*) (Guimarães et al. 2002). The legumes perennial cycle display slower growth with lower biomass yields, compared with the legumes annual cycle, requiring therefore make weed suppression until its complete establishment (Perin et al. 2004). The forage peanut (*Arachis pintoi* , Krap., and Greg.) is native to the Cerrado and has potential for use as forage in pasture, as green cover in perennial crops and as ornamental plant. It is a perennial herbaceous legume and superficial growth, showing stolons that are fixed to the soil by means of abundant roots sprouted from nodes (Nascimento 2006). The perennial soybean (*Glycine wightii*, Verdc.) originated in Africa with climbing habit of growth, producing on average 20 to 30 t.ha $^{-1}$ of green mass and 6 to 8 t.ha $^{-1}$ of dry mass per year. Its root system is very vigorous and deep, may compete for water and nutrients with companion crops, requiring observe the appropriate period of mowing with management. The initial growth of this legume is slow and it requires an initial weed control (Formentini 2008).

Using peanut and perennial soybean in intercropping in coffee production in the Cerrado region of Minas Gerais, Santos et al (2013) found that one year after the establishment, there was great soil cover shows the good capacity to suppress weeds. Thus, intercropping and management of species of perennial legumes in coffee production may provide a soil cover and reduce weed infestation. Therefore, the aim of this study was to evaluate the soil cover and weed infestation in coffee, intercropping and subjected to different management of two species of perennial legumes.

Material and Methods

The experiment was conducted from february 2009 to april 2010, in Patrocínio, MG, at the altitude of 972 m e geographical coordinates 18º 53' south latitude and 46º 56' west longitude. The soil was classified as clayey eutroferric oxisoil (EMBRAPA 2006), and the coffee plantation 11 years old, catuaí red cultivar IAC-99 lineage and spacing 3,80 x 0,70 m . The data of rainfall and maximum and minimum temperatures were consolidated during the experiment (Figure 1).

The experiment consisted of nine treatments in a factorial 2^3 +1 scheme, the factors were the intercalation of perennial legumes species forage peanut (*Arachis pintoi*) and perennial soybean (*Glycine wightii*); with and without legumes lateral management using glyphosate (1,0 kg.ha^{-1} acid equivalent) at 50 cm from the projection of the skirt, every two months october 2009 to april 2010; and yet, without and with vertical management with cutting legume 5 cm of soil , every two months october 2009 to april 2010. In additional treatment or control treatment was used glyphosate (1,0 kg.ha^{-1} acid equivalent) in the interrows of plot, every two months october 2009 to april 2010.

The experimental design was a randomized block with four replications and plots formed by three lines seven coffee plants, with treatments applied in the two lines. The legumes were sown in february 2009, in two rows spaced 50 cm with a density of 20 seeds for lineal meter and fertilization in the equivalent of 50 kg.ha^{-1} P_2O_5. From february 2009 to september 2009 effected two hand hoeing for weed suppression and from october 2009 to april 2010 occurred managements of legumes. The soil correction and fertilization was based on soil analysis and observations in crop (Guimarães et al. 1999), and the pest control and other driving practices as Matiello et al. (2010).

The soil cover was evaluated immediately after management of each treatment at 8, 10, 12 and 14 months of legumes sowing.

The method utilized was the launch of the mesh equal squares, which form the points perpendiculars intersections between two strings stretched every 10 cm, in a wooden frame of 1,0 x 1,0 m, the sum of these points on vegetation corresponds to the percentage soil cover (Favero et al. 2001), equivalent to counting the squares on the legumes vegetation for each treatment without the weeds presence, and weeds vegetation of control treatment.

The level of weed infestation was also evaluated after the management of each plot at 8, 10, 12 and 14 months after sowing, using the same method of soil cover (Favero et al. 2001). The percentage of infestation resulted from the sum of the squares of all weeds what were in and out of cover by the legume. In the analysis of variance was used ASSISTAT program (Silva & Azevedo 2009).

The averages of control treatment were compared with the averages of the other treatments by Dunnett's test at 5 % significance. The averages of each factor and their interactions, when significant, were compared by Tukey's test at 5 % significance. The correlations between the variables were performed with the aid of the Excel program, and also applied the test t to assess the significance of the correlation coefficient.

Results and Discussion

The percentage of soil cover, provided by the weeds management with glyphosate herbicide (control) was lower than the soil cover provided by management with legumes (Table 1). This is reinforced, because in the control treatment, the management with glyphosate herbicide was applied to the entire plot, with soil cover vegetation of this management corresponding of weeds vegetation not controlled.

At 8 and 10 months there was not significant interaction between the factors in relation to soil cover by legumes (Table 2). At 8 months (october 2009), forage peanut showed an average cover similar to the cover provided by the perennial soybean. As between themselves, had the same cover with and without side management, and still amongst themselves with and without legumes vertical management. At 10 months (december 2009) the results obtained with the soil cover by legumes, with and without lateral management, and with and without vertical management had similarities as obtained to the 8 months.

The result of the forage peanut in the soil cover keeps the trend of approaching indices obtained by Bradshaw & Lanini (1995), which recorded total soil cover at 90 days after the sowing of that legume and also with the results of Perin et al. (2000), who obtained the highest soil cover at 120 days. The Soil cover by perennial soybean also approaches with the results obtained by Santos et al (2013), who found an average of 69,75 % of soil cover provided by that species.

Similarly, at 12 months (february 2010), there was not significant interaction between the factors, not having influence in the soil cover (Table 3). The forage peanut and perennial soybean provided, significantly, the same soil cover. In the treatments with and without legumes lateral management registered the same soil cover. Also between with and without the vertical management, the soil cover was similar.

There was registration of significant interaction (Table 3) between legumes species and vertical management only at 14 months (april 2010). For forage peanut, there was not statistical difference in soil cover between the vertical management compared to without the vertical management. For perennial soybean, the soil cover with vertical management was less than the treatment without the vertical management. Independent of the legume species, the lateral management with glyphosate at 50 cm from the projection of the coffee skirt showed the same soil cover of the treatments without lateral management.

In the establishment phase, the growth rates of perennial legumes are initially slow, when compared with annual legumes (Perin et al. 2004). Therefore, the first evaluations after the drought, at 8 and 10 months, showed up with a smaller soil cover compared with the latest evaluations during the rainy season (12 and 14 months).

The non achievement of area total cover during the rainy season (8 to 14 months), was probably due to the fact that legumes were sown at the end of the previous rainy season (february), and the evaluations performed after a drought period, having reduction in plant mass due to the influence of the dry season.

At 8 months (october 2009), there were no differences in weed infestation of any management with legume compared to management with glyphosate (Table 4). At 10 months (december 2009), only the treatment corresponding to peanut with lateral management and without vertical management presented a higher weed infestation, compared to management with glyphosate.

At 12 months (february 2010), the weed infestation, provided by management with glyphosate was significantly surpassed by the forage peanut without lateral management and by perennial soybean without lateral management. At 14 months (april 2010), the weed infestation in the management with glyphosate was surpassed only by forage peanut with lateral management and without vertical management, and also, by the same species without lateral management and with vertical management.

The forage peanut with lateral and vertical management, and perennial soybean with lateral management, there was not difference in the weed infestation in relation to management of the control treatment with glyphosate. The most soil cover, provided by these species and their managements probably caused a greater inhibition of weeds. The results combine with reached them by Lanini & Bradshaw (1995) and Cunha & Alvarenga (2003), when comparing the intercropped of legumes with peanut, hand weeding and chemical control, found that these species had the greatest influence on inhibition of weed infestation of coffee.

The results also coincide in part with those obtained by Santos et al (2013), whose lateral and vertical management form perennial legumes forage peanut (*Arachis pintoi*), perennial soybean (*Neonotonia wightii*), java hybrid (*Macrotyloma axillare*) and wild ground nut (*Calopogonium mucunoides*) had lower weed infestation under the influence of the forage peanut intercropping in the first year, but the second year, the perennial soybean provided lower infestation compared to chemical control with glyphosate.

In the evaluations of weed infestation there was not significant interaction between the factors (Tables 5 and 6). At 8 months (october/2009) the forage peanut provided greater weed infestation in relation to the perennial soybean. With and without the lateral management of the legumes with glyphosate there was the same infestation of the treatments, results also observed for treatments with and without the vertical management.

At 10 months (december/2009) there was not significant difference in the weed infestation between the forage peanut and perennial soybean. The infestation was also similar between lateral management with glyphosate and without the lateral management. In the vertical management, the weed infestation was lower than the treatments without that management.

The results at 12 months (february/2010) showed that there was not difference in the weed infestation for any of the three factors studied (Table 6). The forage peanut showed the same infestation of perennial soybean. The lateral management with glyphosate did not differ from infestation of treatments without lateral management and the vertical management also did not differ from infestation of treatments without the vertical management.

The weed infestation at 14 months (april/2010) was similar to those obtained at 8 months (Tables 5 and 6). The forage peanut had a higher infestation in relation to the perennial soybean. The lateral management of the legumes with glyphosate was not different from infestation of the treatments without lateral management, also observed similar results for the vertical management compared to treatments without the vertical management.

The largest weeds infestations obtained by cultivation forage peanut in the first and fourth evaluation, should be probably to its lower ground cover, compared to the perennial soybean (Santos et al. 2013). Leonidas et al. (2001) found that forage peanut is species more effective in the weed control in the dry and wet periods, which enables workers' reduction and hand weedings.

Cunha & Alvarenga (2003) found that soil green cover with forage peanut in the interrows in the coffee crops formed a dense undergrowth vegetation, reducing weed infestation, with weeding savings and increased protection against the soil erosion. In studies performed with other cultures, also using herbaceous legumes in green manure, it is recorded interference potential of these species to reduce weed populations (Araújo et al 2007; Monquero et al 2009).

The continuous use of herbicides with the same action mechanism promotes the selection of herbicide resistant weeds, being a limitation of world agriculture (Trezzi et al. 2011). The low weed infestation obtained with the legumes cultivation can reduce the use of herbicides, preventing the selection of resistant weeds and meeting the conformities for certification of coffee in the Cerrado (Santos et al. 2008).

In the evaluations there was a significant and negative correlation between the soil cover provided by legumes and weed infestation (Figure 2). As larger the soil cover by legumes, lower wiil be the weed infestation, combining with the results of Severino and Christoffoleti (2001), who found a linear correlation between biomass production and the reduction of these species.

Conclusions

The intercropping forage peanut and perennial soybean provided good soil cover and reduced weed infestation. The forage peanut, with lateral and vertical management, and perennial soybean with lateral management, provided lower weed infestation. There was a negative and significant correlation among the soil cover provided by legumes and weed infestation.

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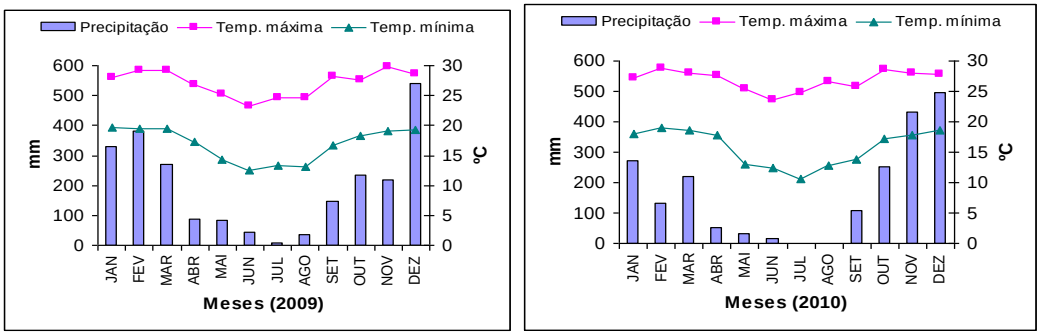

Figure 1: Rainfall (mm), Minimum and Maximum Temperatures (º C) Monthly on Experiment Area (Patrocínio, MG)

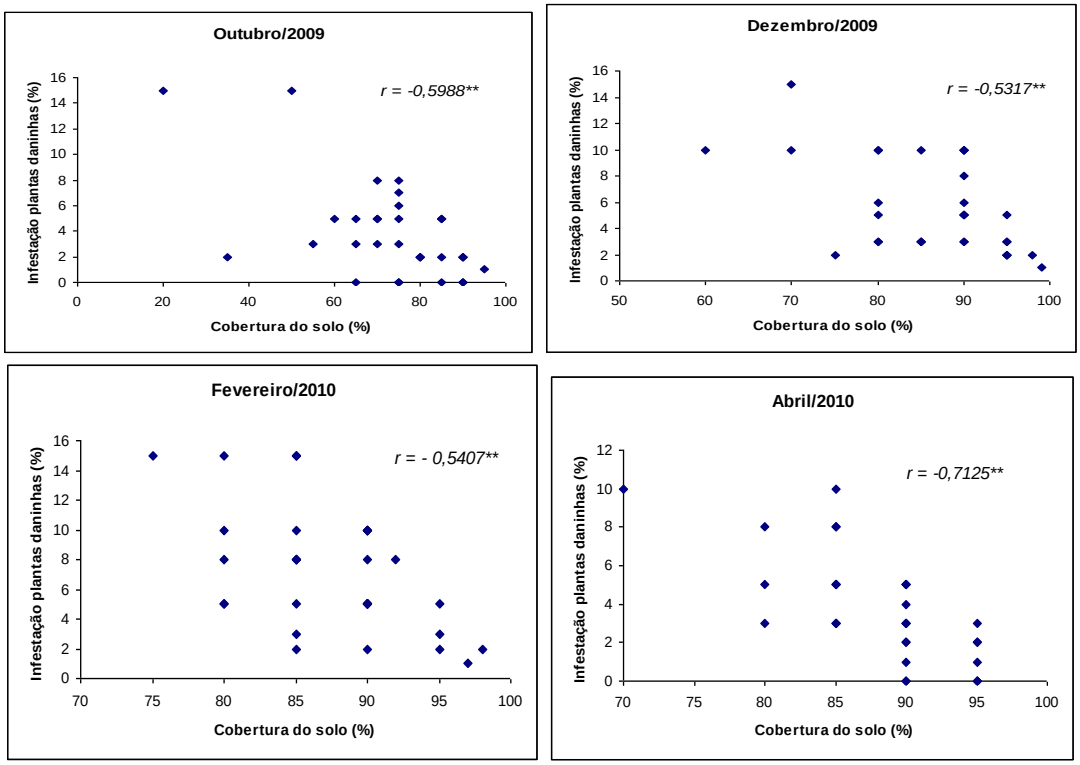

Figure 2: Correlations between Soil Cover by Legumes and Weed Infestation in the Interrows of the Bearing Coffee Crop

Table 1: Soil Cover (%) Provided by Management with Legumes Compared to Management with Glyphosate

	Soil cover (%)			
Treatment [(1)]	8 Months	10 Months	12 Months	14 Months
AF/CML/CMV	80,00*	90,00*	91,25*	91,25*
AF/CML/SMV	51,25*	75,00*	83,75*	82,50*
AF/SML/CMV	73,75*	85,00*	90,50*	87,50*
AF/SML/SMV	80,00*	91,75*	91,25*	90,00*
SP/CML/CMV	75,00*	78,75*	85,00*	85,00*
SP/CML/SMV	70,00*	92,50*	85,00*	90,00*
SP/SML/CMV	72,50*	85,00*	88,75*	85,00*
SP/SML/SMV	83,75*	92,50*	85,00*	93,75*
Glyphosate	6,50	4,00	0,25	0,50
DMS Dunnett	28,27	14,52	9,95	9,74

(1) AF: forage peanut; SP: perennial soybean ; CML: with side management; SML: without side management; CMV: with vertical management; SMV: without vertical management.
* Contrast signifcant by Dunnett 's test at 5 % compared to control (Glyphosate).

Table 2: Soil Cover (%) At 8 and 10 Months Depending on the Species and Management of Perennial Legumes in the Bearing Coffee Crop

	8 MONTHS		
	Legume species [(1)]		
Side management	Forage peanut	Perennial soybean	Means
With	65,63	72,50	69,06 A
Without	76,87	78,12	77,50 A
Means	71,25 a	75,31 a	
Vertical management			
With	76,87	73,75	75,31 A
Without	65,62	76,87	71,24 A
Means	71,25 a	75,31 a	
DMS (species) = 10,21	DMS (management) = 10,21	CV(%) = 21,23	
	10 MONTHS		
	Legume species [(1)]		
Side management	Forage peanut	Perennial soybean	Means
With	82,50	85,62	84,06 A
Without	88,37	88,75	88,56 A
Means	85,43 a	87,18 a	
Vertical management			
With	87,50	81,87	84,68 A
Without	83,37	92,50	87,93 A
Means	85,43 a	87,18 a	
DMS (species) = 5,24	DMS (management) = 5,24	CV(%) = 13,30	

[(1)] Means followed by distinct, tiny lines and capital letters in the columns differ by Tukey test at 5 % significance.

Table 3: Soil Cover (%) At 12 And 14 Months Depending on the Species and Management of Perennial Legumes in the Bearing Coffee Crop

	12 MONTHS		
	Legume species (1)		
Side management	Forage peanut	Perennial soybean	Means
With	87,50	85,00	86,25 A
Without	90,87	86,87	88,75 A
Means	89,18 a	85,93 a	
Vertical management			
With	90,87	86,87	88,87 A
Without	87,50	85,00	86,25 A
Means	89,18 a	85,93 a	
DMS(species) = 3,60	DMS(management) = 3,60	CV(%) = 9,31	
	14 MONTHS		
	Legume species (1)		
Side management	Forage peanut	Perennial soybean	Means
With	86,87	87,50	87,18 A
Without	88,75	89,37	89,06 A
Means	87,81 a	88,43 a	
Vertical management			
With	89,37 aA	85,00 aB	87,18
Without	86,25 bA	91,87 aA	89,06
Means	87,81	88,43	
DMS(species and side manag.)=3,51	DMS(species x vertical manag.)=4,97	CV(%)=9,14	

(1)Means followed by distinct, tiny lines and capital letters in the columns differ by Tukey test at 5 % significance.

Table 4: Weed Infestation (%) in Management Treatments with Legume Against to Management with Herbicide Glyphosate

	Weed infestation (%)			
Treatment (1)	8 Months	10 Months	12 Months	14 Months
AF/CML/CMV	2,75	2,75	5,25	2,25
AF/CML/SMV	7,50	10,25*	9,50*	6,75*
AF/SML/CMV	7,50	5,25	7,00	5,25*
AF/SML/SMV	2,50	5,75	8,25*	4,50
SP/CML/CMV	3,00	3,25	5,75	4,00
SP/CML/SMV	3,75	5,50	3,00	1,00
SP/SML/CMV	3,25	6,00	9,50*	3,75
SP/SML/SMV	0,50	5,75	8,75*	1,75
Glyphosate	6,50	4,00	0,25	0,50
DMS Dunnett	6,34	6,17	7,48	4,64

(1)AF: forage peanut; SP: perennial soybean; CML: with side management; SML: without side management; CMV: with vertical management; SMV: without vertical management.
* Contrast signifcant by Dunnett 's test at 5 % compared to control (Glyphosate).

Table 5: Weed Infestation (%) at 8 and 10 Months Depending on the Species and Management of Perennial Legumes in the Bearing Coffee Crop

	8 MONTHS		
	Legume species [(1)]		
Side management	Forage peanut	Perennial soybean	Means
With	5,12	3,37	4,25 A
Without	5,00	1,87	3,43 A
Means	5,06 b	2,62 a	
Vertical management			
With	5,12	3,12	4,12 A
Without	5,00	2,12	3,56 A
Means	5,06 b	2,62 a	
DMS(species) = 2,29	DMS(management) = 2,29	CV(%) = 55,73	
	10 MONTHS		
	Legume species [(1)]		
Side management	Forage peanut	Perennial soybean	Means
With	6,50	4,37	5,43 A
Without	5,50	5,87	5,68 A
Means	6,00 a	5,12 a	
Vertical management			
With	4,00	4,62	4,31 A
Without	8,00	5,62	6,81 B
Means	6,00 a	5,12 a	
DMS(species) = 2,23	DMS(management) = 2,23	CV(%) = 46,67	

(1)Means followed by distinct, tiny lines and capital letters in the columns differ by Tukey test at 5 % significance.

Table 6: Weed Infestation (%) at 12 and 14 Months Depending on the Species and Management of Perennial Legumes in the Bearing Coffee Crop

	12 MONTHS		
	Legume species [(1)]		
Side management	Forage peanut	Perennial soybean	Means
With	7,37	4,37	5,87 A
Without	7,62	9,12	8,37 A
Means	7,50 a	6,75 a	
Vertical management			
With	6,12	7,62	6,87 A
Without	8,87	5,87	7,37 A
Means	7,50 a	6,75 a	
DMS(species) = 2,70	DMS(management) = 2,70	CV(%) = 58,18	
	14 MONTHS		
	Legume species [(1)]		
Side management	Forage peanut	Perennial soybean	Means
With	4,50	2,50	3,50 A
Without	4,87	2,75	3,81 A
Means	4,68 b	2,62 a	
Vertical management			
With	3,75	3,87	3,81 A
Without	5,62	1,37	3,49 A
Means	4,68 b	2,62 a	
DMS(species) = 1,67	DMS(management) = 1,67	CV(%) = 49,40	

(1)Means followed by distinct, tiny lines and capital letters in the columns differ by Tukey test at 5 % significance.