Journal of Agricultural Science and Technology B 3 (2013) 420-428
Earlier title: Journal of Agricultural Science and Technology, ISSN 1939-1250

Cultivation of Perennial Herbaceous Legumes in Weed Management in Coffee Plantation on the Cerrado

Julio Cesar Freitas Santos[1], Aquiles Junior da Cunha[2], Francisco Affonso Ferreira[3], Ricardo Henrique Silva Santos[3], Ney Sussumu Sakiyama[3] and Paulo Cesar de Lima[4]

1. Brazilian Agricultural Research Corporation-Embrapa, Brasília, Distrito Federal 70770-901, Brazil

2. Agronomy, Academical Center of the Cerrado-Patrocínio, Patrocínio, Minas Gerais 38740-000, Brazil

3. Department of Crop Science, Universidade Federal de Viçosa, Viçosa, Minas Gerais 36571-000, Brazil

4. Minas Gerais Agricultural Research Corporation-Epamig, Viçosa, Minas Gerais 36571-000, Brazil

Received: March 18, 2013 / Published: June 20, 2013.

Abstract: The aim of this study was to evaluate the cultivation of perennial herbaceous legumes on weed control and yield of the coffee crop in the Cerrado. The experimental design was a randomized complete block with four replications. The 10 treatments tested in factorial 4 × 2 + 2, were four legumes: forage peanut (*Arachis pintoi*), hybrid Java (*Macrotyloma axillare*), perennial soybean (*Neonotonia wightii*) and wild ground nut (*Calopogonium mucunoides*); two forms in the interrows of coffee plants with two and three rows of legumes spaced by 0.50 m and 0.25 m, respectively; and two additional treatments consisted of hand weeding with hoe and chemical control with glyphosate. The hybrid Java and wild ground nut in the first year and the hybrid Java and perennial soybean in the second year, all followed by forage peanut, promoted lower density and biomass of the weeds. The wild ground nut in the first year and forage peanut in the second year showed higher soil cover. The hybrid Java had its highest biomass production in two years, and wild ground nut being higher in the first year. The cultivation of perennial herbaceous legumes promoted weed control without interfering in the productivity of the coffee crop.

Key words: Legumes intercropping, soil cover, weed control, coffee crop, weed management.

1. Introduction

Organic matter destructuring, compaction and reduction are the main inductors of the degradation of the soils under Cerrado, the challenge of which is to make systems of production of the greatest energetic efficiency with environmental conservation viable and create technological paradigms of soil and crop management with sustainability [1].

The integrated soil management system with the use of different cropping agricultural and ecological procedures promotes the sustainability with improvements in the physical, chemical and biological quality of soil and contributes towards weed suppression [2].

Corresponding author: Julio Cesar Freitas Santos, Ph.D., research fields: coffee management and weed management. E-mail: julio.cesar@embrapa.br.

Minas Gerais' Cerrado region presents climatic conditions ideal for the growing of traditional and special coffee of excellent beverage quality [3]. Nevertheless, for the sustainable management of its production, practices which minimize the environmental impacts caused by the conduction of the crop with broad spacing, excessive application of chemicals and constant utilization of mechanization.

Inadequate, erroneous and repetitive methods in weed control endanger the sustainability of the coffee plantation because they cause harmful influences to the crop and make the meeting of the conformities of the programs for certification of the production and product in Cerrado region unviable [4].

The integrated management of coffee weeds allows the combination of different control methods aiming at the best coexistence of those infesting species with

the crop and better soil conservation. The soil cover and surface protection practices prevent the surface crust formation and the occurrence of erosive processes, improving the soil fertility by the increase of dry matter and nutrients resulting from the vegetation management [5, 6].

The mulching of soil with legumes decreases the weed infestation [7, 8], and improves soil conditions, implying into less fertilizer and herbicide consumption [9, 10].

Perennial herbaceous legumes should be fast initial growth and good biomass production [11], support moisture limitation and high soil temperatures in the wintertime [12], re-grow after cutting and maintain soil cover, on the contrary of the annual legume plants, which should be re-planted every year [13].

The objective of this work was to evaluate the influence of perennial herbaceous legume plants in weed control and in the production of the coffee crop in Cerrado region**.**

2. Material and Methods

The work was conducted in the period of December of 2006 to July of 2009 in the municipality of Patrocínio, MG, in a crop of coffee Catuaí IAC-99 aged eight years and spacing of 3.80 m × 0.70 m, localized at 18°53′S and 46°56′N at the altitude of 982 m.

2.1 Experimental Design and Treatments

The experimental design was in randomized blocks with four replications, the plots being constituted by three rows of seven coffee plants with the five useful central plants, the treatments of which were applied in a centralized way in the two inter-rows.

The experiment was made up of 10 treatments, arranged in a factorial scheme 4 × 2 + 2, that is, four species of perennial herbaceous species: forage peanuts (*Arachis pintoi*), macrotyloma (*Macrotyloma axillare*), perennial soybean (*Neonotonia wightii*) and calopo (*Calopogonium mucunoides*) and two ways of planting with two and three rows of legumes spaced 0.50 m and 0.25 m, respectively. The two additional treatments were hand weeding with a hoe and chemical control with glyphosate.

The legumes were sown at the density of 40 seeds per linear meter and at the depth of 2 cm, receiving sowing fertilization of 60 kg/ha of P_2O_5. In the two initial months to support the establishment of the legume plants, two hands weeding for the weed control were performed.

The additional treatment of chemical control consisted of glyphosate 360 g/L at the dose of 720 g/ha or 2 L/ha of the commercial product. For its application, a back sprayer of 20 L com spray nozzles TTI 11002, at a pressure of 2 KGF and volume of 150 L/ha was utilized, sprays being done in the months of June, September, December and March. The additional treatment of hand weeding with a hoe was applied in those months.

2.2 Procedures of the Experimental Crop of Coffee

In the rows of the coffee trees, hand weeding were done maintaining clean the 0.80 m strip on each side, over which the establishment and pruning of the legume as far as the end of that weeding strip was delimited. In the first year, the legumes were kept in free growth, there being in the rainy season only one pruning and in the second year two prunnings with mechanized slashing were performed.

The chemical fertilization of the coffee crop was conducted in a split way in the months of October, December, February and April of the two years by utilizing the NPK formulations 20-5-20 at the dosage at broadcast of 150 g/plant per application in all the plots.

Under the procedures of the experiment, the sprouting and pruning procedures of the coffee trees and phytosanitary control in all the plots, the technical production recommendations were followed [14], according to the conditions presented by the crop. Coffee harvest was done by hand detachment on the cloth and the production transported, next, to the drying yard till it reached the content of 12% of moisture.

2.3 Evaluation and Annotation of the Data

The daily annotation and the monthly consolidation of rainfalls were collected from the Automated Weather Station close to the experiment (Fig. 1).

The cover of the soil by the legumes was evaluated in November and February, based upon the equal square network method, formed by perpendicular intersections between two twines stretched on a wooden frame. The intersection among two perpendicular twines defines a point and it represents an area of the covering with vegetation, in that in the evaluation they are counted the sum of those points, making possible the equivalence in percentage of the total area [15]. That method was adapted by the placing at the center of each inter-row of the plot of a rectangular plastic network measuring 1 m × 6 m, formed by 100 quadrants 20 cm in side and 4 cm apart from each other. The percentage of soil cover by the legume was resulting from the count of the squares over the legume vegetation.

The production of the legume biomass was evaluated in November and February by the sampling method of the study of weed population [16]. A wooden frame 0.25 m^2 in area was thrown randomly onto each inter-row of the plot, resulting into the removal and weighing of the sample of 0.50 m^2 of the legume. The sample was dried in an oven with air forced circulation at 65 °C for 72 h for calculation of biomass yield, discounted the area of 60% of the coffee trees.

The density and biomass of the weeds were evaluated in November and February also by the sampling method of the study of the weed population [16]. A wooden frame 0.25 m^2 in area was thrown once in each inter-row of teh plot, resulting into a sampling of 0.50 m^2 of weeds, which were trimmed close to the soil and quantified for determination of the infestation density. Next, those plants were placed into paper bag to dry in oven with forced air circulation at 65 °C for 72 h for determination of the biomass in electronic balance.

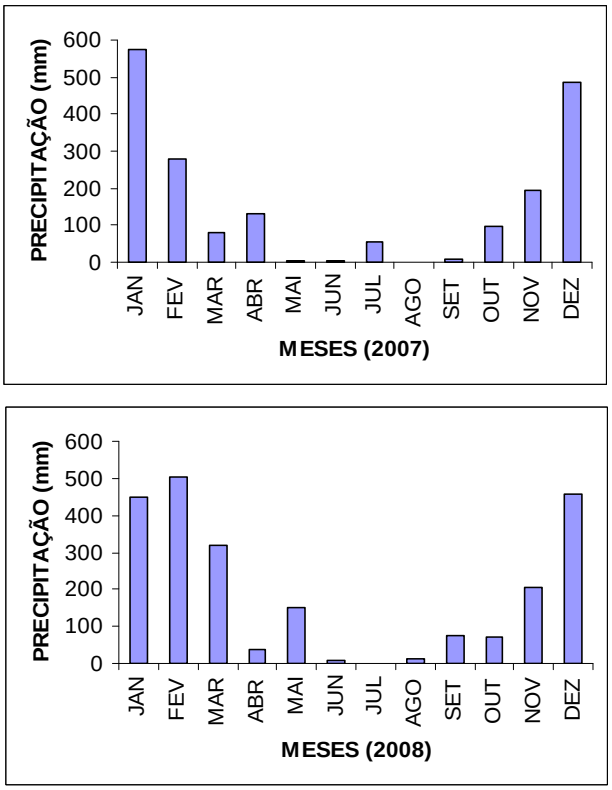

Fig. 1 Monthly rainfalls in the fruit-bearing coffee crop intercropped with perennial herbaceous legumes in Alto Paranaíba region in Minas Gerais, Cerrado, Patrocínio, MG, 2007 and 2008.

The production of coffee was measured in liters of detached fruits, taking a sample of 5 kg for drying at 12% of moisture and calculation of the green coffee yield. In May of each year, the numbers of productive nodes of two plagiotropic branches of each upper, medium and lower third of the coffee trees were counted.

2.4 Statistical Methods and Analyses

The statistical analysis was conducted by the assistant program [17], the contrast of which involving the means of the additional treatments and of the legumes had comparison by the *F* test of the variance analysis at 5% of probability. The means of the factors legumes and rows were compared by the Tukey test at 5% of probability. The data of density and biomass of the weeds were transformed into $(X + 0.5)^{1/2}$ for purposes of normalization of its distribution and conduction of the analyses.

3. Results and Discussion

Calopo promoted greater soil cover in the first year with the forage peanuts being better in the next year (Table 1).

The performance of the calopo in the first year, it was also identical in another experiment, when several perennial legumes was evaluated, with the calopo presented larger tax of soil cover speed rate in relation to the forage peanuts [18].

Although with fast establishment, the calopo in this intercropping with coffee trees was little tolerant to drought, presenting poorer sprout potential after the management with a shredder.

Forage peanuts as a perennial legume has shown slow establishment [19], its being drought-tolerant, though it develops better in moist soils and supported by rainfall [20, 21]. Its propagation is increased by the emission of stolons, creeping growth habit and increased re-growth capacity after pruning, its being promising for permanent soil cover of perennial cultivation without being voluble and aggressive [19].

The legume species, Macrotyloma and perennial soybean, kept themselves in the two periods with an intermediary rate of soil cover, both being aggressive and being able to cause interferences in the coffee trees and limitations in the cropping procedures and harvest.

The growing of two or three rows of legumes in the inter-rows of the coffee trees did not influence soil cover, weeds and coffee yield. Those results agree with those obtained in another experiment, whose planting of perennial legumes being used of the same spacings, it resulted without significant influence in the covering of the soil [21, 22].

Macrotyloma maintained its highest biomass yield in the two years' cultivation (Table 2). Partially, this is due to the fast growth of the plant, voluble growth habit and re-growth capacity. That species requires cares for being aggressive and climbing, its being able to compete with the coffee tree and utilize it as a support for its growth.

Forage peanuts presented the poorest biomass yield in two periods, the results of which poorer than the biomass of the calopo, mainly in the first year, it was also obtained in another research of the cultivation of those species intercropped with coffee tree [23]. The legumes, in the first year, presented poorer biomass yields than in the second year, when those species were already established, reinforcing the fact, that the perennial legumes present expectations of higher production potential and in a steady way after the first year of cultivation [23].

The weed density in the two periods was influenced by the legumes which provide increased reduction in relation to the additional treatments of hand weeding and chemical control (Table 3). Those results agree

Table 1 Soil cover with perennial herbaceous legumes in the coffee crop on the Cerrado, Patrocínio, MG, 2007/2008 and 2008/2009.

Treatments	Soil Cover (%)	
	2007/2008	2008/2009
Legume		
Arachis pintoi	60.50 b	92.25 a
Macrotyloma axillare	71.00 b	72.50 b
Neonotonia wightii	62.25 b	69.75 b
Calopogonium mucunoides	90.25 a	44.75 c
DMS	14.88	16.65
Row		
Two	72.85 a	67.80 a
Three	69.15 a	71.83 a
DMS	13.09	14.33
C.V. (%)	28.71	30.48

Means followed by different letters in the column differ from each other by the Tukey test at 5% of probability.

Table 2 Biomass of perennial herbaceous legumes intercropped with coffee crop on the Cerrado, Patrocínio, MG, 2007/2008 and 2008/2009.

Treatments	Biomass of the legume (kg/ha)	
	2007/2008	2008/2009
Legume		
Macrotyloma axillare	624.16 a	1,784.00 a
Neonotonia wightii	408.00 b	1,372.00 b
Calopogonium mucunoides	668.00 a	928.00 c
Arachis pintoi	252.00 c	444.00 d
DMS	135.60	233.20
Linha		
Two	438.00 a	1,212.00 a
Three	538.00 a	1,052.00 a
DMS	118.00	205.20
C.V. (%)	43.81	35.26

Means followed by different letters in the column differ from each other by the Tukey test at 5% of probability.

Table 3 Density of weeds do coffee plantation on the Cerrado under the cultivation of perennial herbaceous legumes in Alto Paranaíba region, Patrocínio, MG, 2007/2008 and 2008/2009.

Treatments Contrasts[1]	Weed density (plants/m^2)	
	2007/2008	2008/2009
Additional	8.88	13.29
Legumes	5.50*	6.91*
Hand weeding	8.75	15.68
Chemical control	9.00^{ns}	10.90*
Legume[2]		
Macrotyloma axillare	3.25 a	3.57 a
Neonotonia wightii	10.00 b	4.52 a
Arachis pintoi	5.00 a	7.98 b
Calopogonium mucunoides	3.75 a	11.55 c
DMS	2.29	2.76
Row[2]		
Two	5.65 a	6.80 a
Three	5.35 a	7.02 a
DMS	2.03	2.45
C.V. (%)	25.28	22.97

[1]Contrast analysis; *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 each other by the Tukey test at 5% of probability.

with those of the intercropping of perennial herbaceous legumes with coffee crop confirming the influence of soil cover and biomass yield of the legumes in reducing weeds [16].

Macrotyloma stood out for having presented, in a steady way, in the two years, greater influence of the infestation density of the weeds owing to keeping greater biomass yield in that period.

Forage peanuts in the first year and perennial soybean in the second year, both also promoted a greater reduction of weed density, although the same ones had presented the second greatest rate of soil cover in the first year. Forage peanuts presented better perspective for intercropping with coffee crop for the ease of hand and mechanized management, presenting short size, drought resistance and fast re-growth after the first rains, which stimulated the greatest soil cover in the second year, yet with poor biomass yield in relation to the other legumes. Through the confirmation of works about perennial crops, that legume possesses the potential to influence the inhibition of weed species [11, 24, 25].

Perennial soybean allowed the greatest density of weed infestation in the first year, nevertheless, in the

second year, provided greater reduction of those species, perhaps for the fact that it kept in a regular way, the soil cover and biomass yield.

Calopo, despite of being a species of certain allelopathic influence [26], provided little infestation of the weeds only in the first year, however, in the second year, had less influence than the other legumes due to the decreased of its soil cover and biomass yield.

Among the additional treatments, chemical control reduced the infestation density of weeds, mainly in the second year.

The weed biomass in the two periods was influenced by the legumes, which caused increased reduction in relation to the additional treatments (Table 4). That result reinforces the fact that legumes present potential to influence the decrease of weeds in the coffee crop. Among the additional treatments, chemical control in the reduction of the weed biomass production stood out.

Macrotyloma was better in the two years in providing greater fall in the weed biomass production. Calopo in the first year and perennial soybean in the second year, both provided the poorest weed biomass production along with Macrotyloma. Calopo for having presented greatest soil cover and biomass yield in the first year, showed results convergent in obtaining of the less accumulation of weed biomass when that legume was used as a green manure [27].

Forage peanuts kept itself constant as the second legume of greatest influence in inhibiting the weed biomass in the two years. That result is similar to those found in several works with indication of that legume as a soil cover plant and suppressor of the weed infestation of the coffee crop [16, 28] and of other perennial crops [29-31].

Coffee yield proved similar, there being no significant differences among legumes and between these and the additional treatments (Table 5). Legume intercropped with coffee may in the first biennium, not have significant influence in coffee yield [32], however, some species influence in a negative way, yield after the first years of intercropping [32, 33].

Also there were, in the two years, no significant differences of effect between the additional treatments of hand weeding and chemical control on coffee yield, if equaling the other works, who also found no significant differences in the coffee tree production with the exception of those two control methods [34]. The weeds which grow in the inter-rows do not harm the coffee

Table 4 Biomass of the weed of the coffee crop on the Cerrado, intercropped with perennial herbaceous legumes in Alto Paranaíba region, Patrocínio, MG, 2007/2008 and 2008/2009.

Trataments contrasts[1]	Weed biomass (g/m^2)	
	2007/2008	2008/2009
Additional	18.35	22.71
Legumes	11.79*	15.18*
Hand weeding	18.89	25.06
Chemical control	17.80^{ns}	20.36*
Legume[2]		
Macrotyloma axillare	6.72 a	9.00 a
Arachis pintoi	11.82 b	14.46 b
Neonotonia wightii	20.15 c	10.96 a
Calopogonium mucunoides	8.44 a	22.24 c
DMS	2.14	2.31
Row[2]		
Two	11.80 a	14.22 a
Three	11.77 a	14.10 a
DMS	1.13	1.23
C.V. (%)	11.93	10.64

[1]Contrast analysis, *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 each other by the Tukey test at 5% of probability.

Table 5 Green coffee yield under the influence of perennial herbaceous legumes intercropped with coffee trees on the Cerrado in Alto Paranaíba region, Patrocínio, MG, 2007/2008 and 2008/2009.

Treatments contrasts[1]	Coffee yield (bag/ha)	
	2007/2008	2008/2009
Additional	38.10[ns]	24.63[ns]
Legume	38.38	24.50
Hand weeding	39.20[ns]	24.75[ns]
Chemical control	37.00	24.50
Legume[2]		
Arachis pintoi	40.50 a	26.50 a
Macrotyloma axillare	40.00 a	24.25 a
Neonotonia wightii	37.25 a	23.75 a
Calopogonium mucunoides	35.75 a	23.50 a
DMS	5.51	4.60
Row[2]		
Two	37.87 a	25.60 a
Three	38.89 a	23.40 a
DMS	4.88	4.07
C.V. (%)	19.44	22.34

[1]Contrast analysis; [*]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 each other by the Tukey test at 5% of probability.

Table 6 Number of productive nodes of the coffee tree under the influence of the intercropping of perennial herbaceous legumes with coffee crop on the Cerrado, Patrocínio, MG, 2007/2008 and 2008/2009.

Treatments contrasts[1]	Number of productive nodes	
	2007/2008	2008/2009
Additional	7.80[ns]	11.88[ns]
Legumes	7.87	12.16
Hand weeding	7.60[ns]	11.67[ns]
Chemical control	8.00	12.08
Legume[2]		
Arachis pintoi	7.78 a	11.78 a
Macrotyloma axillare	7.48 a	11.90 a
Neonotonia wightii	7.38 a	11.75 a
Calopogonium mucunoides	8.85 a	13.20 a
DMS	1.53	1.59
Row[2]		
Two	7.96 a	12.00 a
Three	7.78 a	12.32 a
DMS	1.33	1.40
C.V. (%)	15.03	18.04

[1]Contrast analysis; *significant; [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.

plant, since a strip in the planting row of the coffee trees in the region of the root and of the fertilization is kept always trailed and under mulch [35].

The influence among legumes, between those and the additional treatments and between the additional treatments of hand weeding and chemical control upon the number of productive nodes of the coffee tree also proved without significant difference in the two years' cultivation (Table 6).

Those results enable to visualize that the growing of perennial herbaceous legumes in the inter-rows of the coffee trees does not present interference in the productive aspects of the crop, since those species had controlled growth with the doing of the adequate management, avoiding the advancement of its establishment in the row of the coffee trees.

4. Conclusions

Legumes promoted less infestation density and poorer weed biomass yield than the additional treatments of hand weeding and chemical control. Macrotyloma along with calopo in the first year and with perennial soybean in the second year, followed of forage peanuts, provided less density and poorer weed biomass. Calopo in the first year and forge peanuts in the second year enabled greatest soil cover. Macrotyloma maintained its biomass yield higher in the two years' cultivation with calopo being higher only in the first year.

The cultivation of two or three rows of legumes did not contrast in all the variables. The influence among legumes, between those ones and the additional treatments and between those latter ones, did not contrast with the number of productive nodes and coffee yield.

The growing of perennial herbaceous legume controlled the coffee weeds on the Cerrado, its being able to constitute the integrated management of those species and decrease the applications of herbicides and weedings.

References

[1] J. Kluthcouski, A.L. Fancelli, D. Dourado-neto, C.M. Ribeiro, L.A. Ferraro, Yield of soybean, corn, common bean and rice under no-tillage management, Scientia Agrícola, Piracicaba 57 (1) (2000) 97-104. (in Portuguese)

[2] E. Voll, E. Torres, A.M. Brighenti, D.L.P. Gazziero, Weed seedbank dynamics under different soil management systems, Planta Daninha, Viçosa 19 (2) (2001) 171-178. (in Portuguese)

[3] L. Coltro, A.L. Mourad, P.A.P.L.V. de Oliveira, J.P.B.O. Andrade, Regional differences of coffee cultivation in Brazil, Coffee Science, Lavras 7 (1) (2012) 31-41.

[4] J.C.F. Santos, B.V. Raij, A.J. de Lima, P.C. Afonso Junior, Evaluation of conformities of producers of the cerrado of Minas Gerais, Brazil, with the norm of integrated coffee production, Coffee Science, Lavras 3 (1) (2008) 7-18. (in Portuguese)

[5] E.N. Alcântara, M.M. Ferreira, Effects of weed control methods in coffee (*Coffea arabica* L.) on soil physical quality, Revista Brasileira de Ciências do Solo, Viçosa, 24 (4) (2000) 711-721. (in Portuguese)

[6] E.N. Alcântara, J.C.A. Nobrega, M.M. Ferreira, Effects of weed control methods on coffee crop on soil chemical attributes, Ciência Rural, Santa Maria 39 (3) (2009) 749-757. (in Portuguese)

[7] J.C. Araújo, E.G. Moura, A.C.F. Aguiar, V.C.M. Mendonça, Suppression of weeds by annual leguminous plants under Amazon agroecological system, Planta Daninha, Viçosa 25 (2) (2007) 267-275. (in Portuguese)

[8] P.A. Monquero, L.R. Amaral, E.M. Inácio, J.P. Brunhara, D.P. Pinha, P.V. Silva, et al., Effect of green fertilizers on the suppression of different species of weeds, Planta Daninha, Viçosa 27 (1) (2009) 85-95. (in Portuguese)

[9] C.L. Bergo, E.P. Pacheco, H.A. Mendonça, J.T.S. Marinho, Evaluation of legume species for coffee plants formation in the segment of family farms in Acre, Acta Amazônica, Manaus 36 (1) (2006) 19-24. (in Portuguese)

[10] G.P. Duda, J.G.M. Guerra, M.T. Monteiro, H. De-Polli, M.G. Teixeira, Perennial herbaceous legumes as live soil mulches and their effects on C, N and P of the microbial biomass, Scientia Agricola, Piracicaba 60 (1) (2003) 139-147.

[11] F.J. Severino, P.J. Christoffoleti, Weed supression by smother crops and selective herbicides, Scientia Agricola, Piracicaba 61 (1) (2004) 21-26.

[12] L.P. Pacheco, F.R Pires, F.P. Monteiro, S.O. Procopio, R.L. Assis, M.L. Carmo, et al., Performance of cover crops oversown onto soybean, Pesquisa Agropecuária Brasileira, Brasília 43 (7) (2008) 815-823. (in Portuguese)

[13] J.A.A. Espindola, J.G.M Guerra, D.L. de Almeida, M.G. Teixeira, S. Urquiaga, Decomposition and nutrient release of perennial herbaceous legumes intercropped with banana, Revista Brasileira de Ciência do Solo, Viçosa 30 (2) (2006) 321-328. (in Portuguese)

[14] J.B. Matiello, R. Santinato, A.W.R. Garcia, S.R. Almeida, D.R. Fernandes, Culture of the coffee in the brasil: New manual of recommendations, Rio de Janeiro: Mapa/Fundação Procafé, 2005, p. 438. (in Portuguese)

[15] C. Favero, I. Jucksch, R.C. Alvarenga, L.M. da Costa, Modifications in the population of spontaneous plants in the presence of green manure, Pesquisa Agropecuária Brasileira, Brasília 36 (11) (2001) 1355-1362. (in Portuguese)

[16] L. Bradshaw, W.T. Lanini, Use of perennial cover crops to suppress weeds in nicaragua coffee orchads, International Journal of Pest Managment, London 41 (4) (1995) 185-194.

[17] F.A.S. Silva, C.A.V. de Azevedo, Assistat computational program version for the windows operating system, Revista Brasileira de Produtos Agroindustriais, Campina Grande 4 (1) (2002) 71-78. (in Portuguese)

[18] J.A.A. Espindola, J.G.M. Guerra, D.L. de Almeida, M.G. Teixeira, S. Urquiaga, Evaluation of perennial herbaceous

legumes with different phosphorus sources and levels in Brazilian ultisol, Renewable Agriculture and Food Systems, Cambridge 20 (1) (2005) 56-62.

[19] A. Perin, M.G. Teixeira, J.G.M Guerra, Perfomance of some legume plants with potencial for use as a permanebt living mulch of soil, Revista Agronomia, Seropédica 34 (1/2) (2000) 38-43. (in Portuguese)

[20] J. Fidalski, C.J. Marur, P.A.M. Auler, C.A. Tormena, Orange yield in orchard floor vegetation management, Pesquisa Agropecuária Brasileira, Brasília 41 (6) (2006) 927-935. (in Portuguese)

[21] A. Perin, J.G.M. Guerra, M.G. Teixeira, Soil coverage and nutrient accumulation by pinto peanut, Pesquisa Agropecuária Brasileira, Brasília 38 (7) (2003) 791-796. (in Portuguese)

[22] A. Perin, J.G.M. Guerra, M.G. Teixeira, E. Zonta, Soil cover and nutrient accumulation of two perennial legumes as functions of spacing and planting densities, Revista Brasileira de Ciência do Solo, Viçosa 28 (1) (2004) 207-213. (in Portuguese)

[23] E.S. Matos, E.S. Mendonça, P.C. de Lima, M.S. Coelho, R.F. Mateus, I.M. Cardoso, Green manure in coffee systems in the region of zona da mata, minas gerais: Characteristics and kinetics of carbon and nitrogen mineralization, Revista Brasileira de Ciência do Solo, Viçosa 32 (5) (2008) 2027-2035.

[24] A.J. da Cunha, M.A. Ranal, J.P.R. de Oliveira, P. Umeda, A.A. Ferrante, Allelopathy effect of *Arachis pintoi* in the *Bidens pilosa* germination and *Ipomoea triloba*, Cerrado Agrociências, Patos de Minas 1 (1) (2010) 15-25. (in Portuguese)

[25] F.J. Severino, P.J. Christoffoleti, Effects of cover crop biomass quantities on weed suppression, Planta Daninha, Viçosa 19 (2) (2001) 223-228. (in Portuguese)

[26] A.P.S. Souza Filho, S.M. Alves, F.J.C. Figueiredo, Allelopathic effects of calopo according to its age and to seed density of the receiver plant, Planta Daninha, Viçosa 21 (2) (2003) 211-218. (in Portuguese)

[27] M.R.M. Silva, Z.B.B. Souza, E.A. Costa, D.R. Campos, Green fertilizers in the handling of the weeds, in: Congresso Brasileiro da Ciência das Plantas Daninhas, Ribeirão Preto, Anais, Londrina, pr: Sbcpd, 2010, pp. 984-988. (in Portuguese)

[28] V. Aguilar, C. Staver, P. Milberg, Weed vegetation response to chemical and manual selective ground cover management in a shaded coffee plantation, Weed Research 43 (2003) 68-75.

[29] J.A.A. Espindola, J.G.M. Guerra, A. Perin, M.G. Teixeira, D.L. Almeida, S. Urquiaga, et al., Banana plants intercropped with perennial herbaceous legumes used as living mulches, Pesquisa Agropecuária Brasileira, Brasília 41 (3) (2006) 415-420. (in Portuguese)

[30] B.F. Mullen, I.K. Rika, D.A. Kaligis, W.W. Stur, Performance o grass-legume pastures under coconuts in indonésia, Experimental Agriculture, New York 33 (4) (1997) 409-423.

[31] A.C. Rincón, J.O. Orduz, Alternatives uses of *Arachis pintoi*: Promising echotypes as cover crop in the citric cultivation, Pasturas Tropicales, Cali 26 (2) (2004) 2-8.

[32] E.M. Paulo, R.S. Berton, J.C. Cavichioli, E.A. Bulisani, F.S. Kasai, Productivity of grafted coffee during intercropping with five leguminous species in the western region of são paulo state, Brazil, Bragantia, Campinas 65 (1) (2006) 115-120. (in Portuguese)

[33] E.M. Paulo, R.S. Berton, J.C. Cavichioli, E.A. Bulisani, F.S. Kasai, Coffee productivity during intercropping with five leguminous species in the Western region of são paulo state, Brazil, Bragantia, Campinas 60 (3) (2001) 195-199. (in Portuguese)

[34] S.V. de Toledo, M.V. de Moraes, I. de Barros, Effects of weeding frequency on coffee yield, Bragantia, Campinas 55 (2) (1996) 317-324. (in Portuguese)

[35] P.C. de Lima, W.A.A. de Lima, Spontaneous plants as green fertilizers in the organic coffee growing, Agroecology-today, Botucatu, ano iv 22 (2003) 26. (in Portuguese)