DECOMPOSITION AND NITROGEN MINERALIZATION FROM GREEN MANURES INTERCROPPED WITH COFFEE TREE

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ABSTRACT: The knowledge about the rate of decomposition and nitrogen mineralization of green manures provides synchronization with the higher absorption stage by the coffee tree. The rate of decomposition and nitrogen mineralization varies according to the species of green manure and with the environmental factors. The aim of the present study was to evaluate the decomposition and nitrogen mineralization of two green manures intercropped with coffee trees for three different periods. The experiment was divided into two designs for statistical analysis, one referring to the characterization of plant material (fresh mass, dry matter, dry matter content, nitrogen concentration and accumulation in the jack bean (*Canavalia ensiformis*) and hyacinth bean (*Dolichos lablab*) and another to evaluate the rate of decomposition and N mineralization of these species. The decomposition rate decreased in both species as their growth time increased in the field. The decomposition was influenced by the phenology of green manures. Nitrogen mineralization of the jack bean decreased as the growth period in the field increased and was faster than hyacinth bean only when cut at 60 days. The N mineralization was slower than mass decomposition in both species.

Index terms: *Coffea arabica* cv. Oeiras, *Canavalia ensiformis*, *Dolichos lablab*, decomposition rate, nitrogen cycling.

DECOMPOSIÇÃO E MINERALIZAÇÃO DO NITROGÊNIO PROVENIENTE DE ADUBOS VERDES CONSORCIADOS COM CAFEEIROS

RESUMO: O conhecimento sobre a taxa de decomposição e mineralização de nitrogênio dos adubos verdes possibilita uma sincronia com o estádio de maior absorção pelo cafeeiro. A taxa de decomposição e mineralização de nitrogênio variam com a espécie de adubo verde utilizado e com os fatores ambientais. O objetivo deste trabalho foi avaliar a decomposição e a mineralização de nitrogênio de dois adubos verdes, consorciados com cafeeiros por três períodos diferentes. O experimento foi separado em dois para análise estatística, sendo um referente à caracterização do material vegetal (massa fresca, massa seca, teor de massa seca, concentração e acúmulo de nitrogênio no feijão-de-porco e lablabe) e outro para avaliação da taxa de decomposição e mineralização do N dessas espécies. A taxa de decomposição reduziu em ambas as espécies à medida que se aumentou o tempo de crescimento destas no campo. A fenologia dos adubos verdes influenciou sua decomposição. A mineralização do nitrogênio do feijão-de-porco foi mais lenta à medida que aumentou o período de crescimento no campo e foi mais acelerada que da lablabe apenas quando cortado aos 60 dias, apresentando similaridade aos 90 e 120 dias e a mineralização do N foi mais lenta que a decomposição da massa, em ambas as espécies.

Termos para indexação: *Coffea arabica* cv. Oeiras, *Canavalia ensiformis*, *Dolichos lablab*, taxa de decomposição, ciclagem de nitrogênio.

1 INTRODUCTION

Over 90% nitrogen in soils is in the form of organic N, composed by different molecules, with varying recalcitrance degrees, or as part of living organisms. The N in the organic form is released during the mineralization as inorganic N (NO_3^- and NH_4^+) and, this process is one of the main N sources of the crops (CANTARELLA, 2007).

In the coffee tree, the N concentration is considered as adequate when between 2.6 and 3.0% N in the leaves. To reach such values, annual applications from 175 to 300 kg ha^{-1} N are required in order to produce between 20 and 60 bags ha^{-1} (GUIMARÃES et al., 1999). An alternative to provide this nutrient within the organic management is the green manure with legumes, since it contributes to the nutrition of subsequent crops. However, green manure with legumes intercropped with coffee trees is a challenge to be overcome, considering that despite the great contribution of mass and N, coffee productivity may or may not be benefited by the intercropping (PAULO et al., 2006).

Legumes have is the low C/N ratio when compared to plants from other families. This characteristic, together with the great presence of soluble compounds, favors its decomposition

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and mineralization by soil microorganisms and nutrient cycling (CANTARELLA, 2007).

The efficiency of N recovery by crops is related to the timing between the N released by green manures and the absorption by plants (FONTANETTTI et al., 2006). Therefore, it is essential to know the decomposition dynamics of green manures in order to estimate the best period for mass distribution in the field, aiming at the synchronization between the mineralization time of nutrients to the soil and the greater absorption stage by the plant of interest. The mass decomposition rate varies according to the species (THOMAS; ASAKAWA, 1993) and to the environmental factors such as temperature, humidity, aeration, organic matter content in the soil, which influence the activity of decomposer microorganisms. The jack beans (Canavalia ensiformis (L.) DC. is considered as one of the most suitable green manure species for intercropping, since it accepts partial shading by the main crop. It has rapid initial growth, thus precluding the establishment of invasive species. Another species with high intercropping potential is hyacinth bean (Dolichos lablab L.), which has slow initial growth and high mass accumulation at the end of the cycle, yielding 18-30 tons of fresh mass per year^{-1} (Brazilian agricultural research agency - EMBRAPA, 2004).

In studies on the decomposition of intercropped legumes to coffee plants, it was observed that Pinto peanut (Arachis pintoi Krapov. & W. C. Greg.) chaff increased height, crown diameter, crown volume and number of plagiotropic branches of the coffee tree in relation to nitrogen fertilization (FIDALSKI; CHAVES, 2010). It was also observed that the shoot of the velvet bean (Mucuna pruriens L. DC) contributed to the increase of the stem diameter, number of nodes, crown diameter and number of leaves of the coffee tree (VILELA et al., 2011). These results evidence how the use of green manures such as legumes in coffee growing can provide greater growth and development of the coffee tree.

The aim of the present study was to evaluate the decomposition and nitrogen mineralization of two green manures intercropped with coffee trees for three different periods.

2 MATERIAL AND METHODS

The experiment was carried out at the Research vegetable garden of the Universidade Federal de Viçosa, MG, Brazil, at 20°45'14" S and 42°52'53" W and 650 m altitude, in a soil classified as cambisol. The climate is Cwa according to the Köppen classification.

The soil, under organic fertilization, showed the following chemical characteristics at the beginning of the experiment in the 0-20 cm depth layer: pH (H_2O) = 6.0; Ca = 2.0 mg dm^{-3}; Mg = 0.7 mg dm^{-3}; Al = 0.0 cmol$_c$ dm^{-3}; H+Al = 3.96 cmol$_c$ dm^{-3}; K = 69 mg dm^{-3}; P = 14.8 mg dm^{-3}; cation exchange capacity (CEC) = 68.4%; V = 42%.

Seedlings of *Coffea arabica* L. cv. Oeiras, purchased in a trustworthy commercial nursery, were transplanted on December 10, 2007, at a spacing of 2.80 x 0.75 m, resulting in a population of 4,761 plants ha^{-1}. Basal and topdressing fertilization were based on the recommendations of Guimarães et al. (1999) for coffee tree (Table 1). The topdressings were performed every 30 days in the rainy season with poultry litter and castor bean cake, according to nutritional requirements. Basal fertilization consisted of 3.0 L poultry litter pit^{-1} (750 g DM pit^{-1}), 300 g thermophosphate pit^{-1} and 50 g limestone pit^{-1}. After the setting of seedlings, 325 g plant^{-1} dry matter of poultry litter (5 g plant^{-1} N per application) was applied in two plots, in December and January 2008.

The fertilization of the first year (2008/2009) was performed with poultry litter, applying 653.25 g plant^{-1} dry matter (10 g plant^{-1} N per application) in three plots in November and December 2008 and January 2009, considering that only 70% N would be available. Topdressing fertilizations performed in October, November, December 2009 and January 2010 were calculated according to expected productivity, since the crop showed a yield perspective already in the second year after planting. Through the evaluation of some edge plants, a productivity of 60 bg ha^{-1} was admitted. Following the recommendation of Guimarães et al. (1999), of 300 kg ha^{-1} year^{-1} N, 350 g plant^{-1} fresh mass (304.85 g plant^{-1} dry matter) of castor bean cake was applied in the first plot, totaling 15.15 g N plant^{-1}, since it was considered that 85% N would be available. In the second plot, 1,800 g plant^{-1} fresh mass of poultry litter (1,044 g plant^{-1} dry matter) was applied, totaling 13.3 g N plant^{-1}, considering the availability of 70% N. In the third plot, 440 g plant^{-1} fresh mass of castor bean cake was applied (383.24 g plant^{-1} dry matter), totaling 19.05 g N plant^{-1}, considering the availability of 85% N. In the fourth plot, 350 g plant^{-1} fresh mass of castor bean cake was applied (304.7 g plant^{-1} dry matter), totaling 15.5 g N plant^{-1}, with availability of 85% N.

TABLE 1 - Fertilization performed in coffee plantation in the 2008/2009 and 2009/2010 crop years.

Fertilization[1]		Limestone	Thermophosphate	Poultry litter	Castor bean cake
		---------- g pit^{-1} ----------		------- g DM pit^{-1}-------	
	Planting	50.00	300.00	750.00	---
	(Dec/Jan 2008)	---	---	325.00[2]	---
	1st year (2008/2009)	---	---	653.25[3]	---
Mulch		---	---	---	304.85
	2nd year (2009/2010)	---	---	1044.00	---
		---	---	---	383.24
		---	---	---	304.70

[1] Values calculated considering the recommendation of 300 kg ha^{-1} year^{-1} N (GUIMARÃES et al., 1999);
[2] Applied in two plots; [3] Applied in three plots.

The legumes jack bean (*C. ensiformis)* and hyacinth bean (*D. lablab)* were chosen because they showed growth habits and contrasting crop cycles. The legumes were previously inoculated with the rhizobia strains *Bradyrhizobium* sp. and *Bradyrhizobium elkanii*, respectively, and sown in three lines between the coffee lines, spaced 0.4 m apart, at the density of six seeds per linear meter, in October 2008, occupying the entire plot of six useful coffee plants. The legumes were cut 30 days after sowing (DAS) in November 2008, at 60 DAS (Dec 2008), at 90 DAS (Jan 2009) and at 120 DAS (Feb 2009) for the mass characterization (fresh mass, dry matter, dry matter content, nitrogen concentration and nitrogen accumulation). The statistical design consisted of a 2x4 factorial design and five replications. The treatments were two intercrops between coffee and legumes (coffee+jack bean and coffee+hyacinth bean) and four intercropping periods (30, 60, 90 and 120 days after sowing of the legume - DASL). The experiment was arranged in complete randomized block design.

The decomposition experiment followed the complete randomized block in a (2x3) x 9 factorial design. The treatments were two legume species (jack bean and hyacinth bean), three cutting times (60, 90 and 120 DAS) and nine subplots composed by the collection dates (0, 3, 7, 12, 18, 25, 32, 40 and 60 days after legume cutting), with four replicates.

The legumes were sampled in 1,0 m^2, being cut at ground level. The fresh mass of this sample was quantified and 100 g subsamples were taken from this 1,0 m^2 at different cutting dates, according to the treatments.

For the decomposition experiment, there was no collection at 30 DAS because there was little mass available for assembling the nine subplots. Subsequently, the 100 g subsamples were washed in deionized water and placed in a convection oven at 70 °C until constant weight was reached. After this process, the dry matter of samples was determined and ground in a Wiley mill with a 20-mesh sieve and stored for further chemical analyses.

A total of 36 samples (nine dates after cutting and four replicates) of 100 g fresh mass of each legume were collected in every period (60, 90 and 120 DAS) and distributed in the crown projection of coffee plants, in their respective plots. Each sample was covered with a nylon mesh (4 mm^2) and 20 x 20 cm size, which were attached to the ground through wires in order to prevent material loss. The same stem/leaf ratio that green manures were harvested in the field was maintained, i.e. the percentage of stems and leaves in 1,0 m^2 sampled was the same percentage of stem and leaves in the 100 g samples, distributed under the mesh in the cleaned soil. At each collection date, all the material of decomposing green manures remaining on the soil was collected, cleaned of dirt and dried for the laboratory analyses described above.

The variables in green manures were fresh mass (FM) and dry matter (DM), dry matter content (DMC), nitrogen concentration (NC) and nitrogen accumulation (NAC).

The dry matter content (DMC) was calculated by the equation DM x 100/FM. The N concentration was determined by the Kjeldahl method, modified by Cotta et al. (2007), and the N accumulation calculated by the equation NC x DM /100. All calculations were performed considering only the area occupied by the legumes, thus disregarding 50% of the area occupied by coffee trees.

Dry matter and nitrogen concentration were evaluated in the remaining mass of green manures, taken from the soil under mesh at each collection date, and the data were expressed as percentage (%) of the initial mass. The rate of mass decomposition and nitrogen mineralization were determined at each period using the exponential mathematical model described by Thomas and Asakawa (1993):

$C = Co\ e^{-kt}$

Where C is the amount of dry matter or nitrogen remaining after the time t, in days; Co is the amount of initial dry matter or nitrogen. The half-life time ($T_{1/2}$), i.e., the time required to lose half of the plant biomass and release half of the nitrogen at the initial time was calculated based on the k values, a constant of the mathematical model, where: $T_{1/2} = \text{Ln } 0.5 / k$.

The decomposition and mineralization data were submitted to analysis of variance and regression at 5% probability level. The analysis were performed using the System for Statistical and Genetic Analyses (FUNDAÇÃO ARTHUR BERNARDES, 2007). The regression models were chosen based on the significance of the regression coefficient using the t test, adopting 5% probability level and the biological phenomenon under study.

3 RESULTS AND DISCUSSION

There was an effect of interaction between species and intercropping period on the variables, FM, DM, DMC, NC and NAC (Table 2).

At 60 days after planting, there was a higher fresh mass accumulation by the jack bean and at 120 days a higher accumulation by the hyacinth bean (Table 3), evidencing a higher initial growth of the jack bean (Figure 1A). Afterwards, an increased growth of the hyacinth bean was observed, overcoming jack bean and showing higher fresh mass accumulation at the final evaluation date at 120 days (Table 3).

The DM accumulation increased over time in both species (Figure 1B), reaching more than 5.0 t ha^{-1} at 120 days, discounting the area occupied by coffee trees (Table 3). The DM accumulation in the jack bean exceeded the hyacinth bean at 60 and 90 days of intercropping (Table 3). The results are different from the ones found by Moreira et al. (2014), which reported a higher DM accumulation of hyacinth bean in relation to jack bean at 90 and 120 days of intercropping with adult coffee trees.The jack bean showed higher DMC than the hyacinth bean at 90 and 120 days of intercropping (Table 3), possibly due to the presence of pods already formed in this species. There was no regression fitting for these data.

Regarding the N concentration, the jack bean exceeded the hyacinth bean only at 60 days of intercropping (Table 3). The adjusted regression models show an opposite performance of the green manure species (Figure 2A). According to Moreira et al. (2014), the N concentrations in jack bean were 3.5, 3.86, 3.10, and 3.05% at 30, 60, 90 and 120 days of intercropping, respectively, similar to the found in the present experiment. For the hyacinth bean, in the same periods, the values found were different, being the concentrations of 3.13, 3.71, 3.41 and 3.03%.

There was increasing N accumulation until the end of the evaluations in both species (Figure 2B). Jack bean grew faster than hyacinth bean and accumulated triple N at 60 days and twice N at 90 days of intercropping (Table 3). Moreover, it produces twice mass and concentrates 1.5 times more N at 60 days, and 1.5 times more mass and concentrates 1.1 times more N at 90 days.

The cutting of green manures in its flowering and pod formation raises the species potential to provide nutrients to the crop. During this period, large amounts of mass accumulate and large amounts of nutrients are recycled. Furthermore, there are no risks for infestation of areas, since the plants are cut before beginning the seed maturation process. However, these results are largely dependent on the growth rate of the species. The earlier and faster growth - such as jack bean - provides a more abundant mass up to 90 days after emergence (MORAES et al., 2008).

At 120 days, there was no statistical difference between the N accumulation in the jack bean and the hyacinth bean (Table 3). A lower value was reported by Moreira et al. (2014), which obtained 111.37 kg ha^{-1} N in the hyacinth bean, also at 120 DAS. This same author reported 71.52 kg ha^{-1} N in the jack bean at 120 days, which is lower than the found.

TABLE 2 -Summary of analysis of variance referring to the fresh mass (FM), dry matter (DM), dry matter content (DMC), nitrogen concentration (NC) and nitrogen accumulation (NAC) of legumes jack bean and hyacinth bean for four periods (30, 60, 90 and 120 days after sowing) in 2008/2009.

F.V.	GL	Mean square				
		FM	DM	DMC	NC	NAC
Species (Sp)	1	2.67	2.63**	17.42**	1.58**	5260.66**
Growing period (G)	3	1566.56**	47.87**	13.53**	0.64**	43926.85**
Sp x G	3	63.19**	1.35*	6.11**	0.94**	2263.26**
Residue	28	448.85	0.43	1.30	0.14	576.63
CV (%)		28.85	27.36	6.59	12.72	32.05

(**) (*) values significant at 1% and 5% probability, respectively, by F test; fresh mass (FM), dry matter (DM), dry matter content (DMC), nitrogen concentration (NC) and nitrogen accumulation (NAC)

TABLE 3 - Accumulation of fresh mass (FM), dry matter (DM), dry matter content (DMC), nitrogen concentration (NC) and nitrogen accumulation (NAC) in the green manures jack bean (JB) and hyacinth bean (HB) cut at 30, 60, 90 and 120 days of intercropping with coffee trees (DAS), in the 2008/2009 crop year.

Cutting (DAS)	FM		DM		DMC		NC		NAC	
	JB	HB	JB	HB	JB	HB	JB	HB	JB	HB
	t ha^{-1}				%				kg ha^{-1}	
30	2.23 A	0.76A	0.42A	0.13A	18.86A	17.51A	2.67A	2.65A	11.17A	3.53A
60	10.60 A	5.27B	1.61A	0.85B	15.20A	16.00A	3.68A	2.40B	59.32A	20.36B
90	17.86 A	13.14A	3.49A	2.12B	19.34A	16.40B	3.45A	3.09A	121.60A	65.68B
120	27.76 B	33.39A	5.10A	5.47A	18.41A	16.63B	2.95A	3.01A	153.39A	164.17A

Means followed by the same letter on the row for each variable and at every date do not differ among themselves by F test ($p \geq 0.05$).

The dry matter and N accumulation curves show similar regression models (Figure 1B and 2B), indicating a constant growth up to 120 days of intercropping. Similar pattern of curves indicates the dependence of N accumulation in relation to the accumulated dry matter.

The experiment was performed in the rainy season, favoring the mass decomposition and N mineralization. In both species, the kinetics of the legume decomposition process showed higher rates when cut at 60 days than at 90 and 120 days, according to the values of the constant k (Table 4 and Figure 3A).

When cut at 60 DAS, the jack bean mass decomposed faster than the hyacinth bean, and less sharply when cut at 90 DAS (Figure 3A). At 120 DAS, the inverse was observed, probably due to the presence of pods in the jack bean, which is a material more lignified and therefore more resistant to decomposition, while the hyacinth bean began the flowering at this date.

In all cutting dates and in both species, the average time of 50% mass decomposition (T½) occurred between 9 and 24 days (Table 4), when there is a greater content of soluble compounds that are more labile and easily decomposed.

The environmental factors such as temperature, humidity, aeration and organic matter content in the soil act on soil microorganisms, which are the main agents in the decomposition process. In December 2008, the rainfall was 705 mm, much higher than the 292 mm in January 2009 and 243 mm in February 2009, contributing to a faster decomposition of legumes cut at 60 DAS. The average temperatures found in the months of Dec 2008, Jan 2009 and Feb 2009 were 20.6 °C, 21.3 °C and 19.8 °C, respectively.

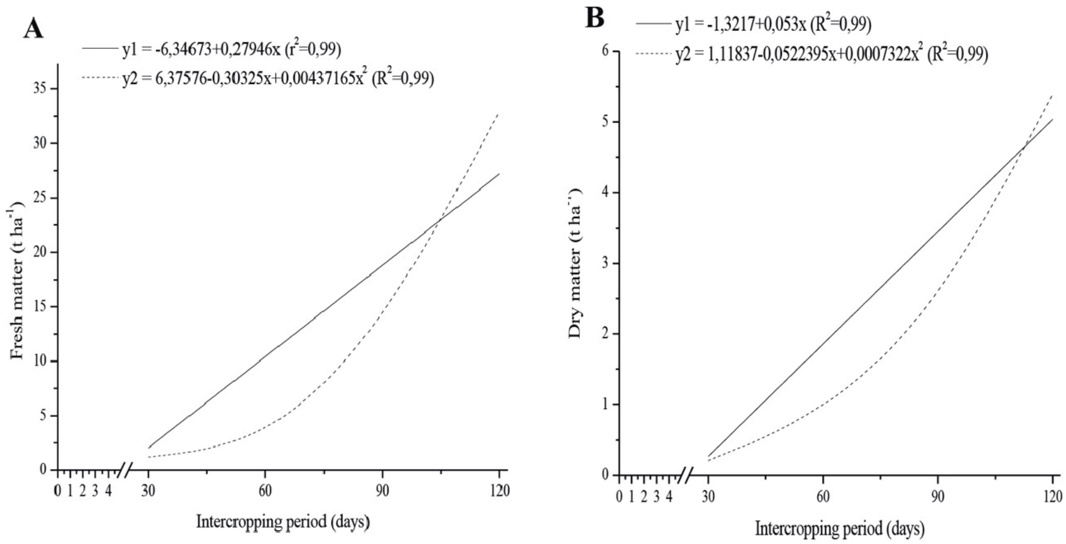

FIGURE 1 - Fresh (FM, A) and dry (B) matter accumulation of the green manures jack bean (y1) and hyacinth bean (y2) intercropped with coffee trees in 2008/2009.

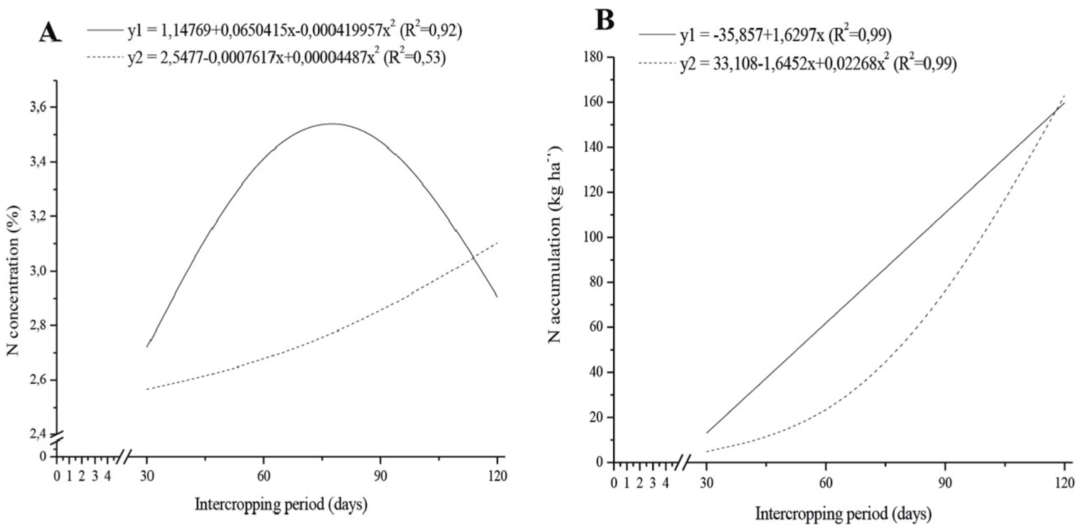

FIGURE 2 - Nitrogen concentration (A) and accumulation (B) in jack bean (y1) and hyacinth bean (y2) intercropped with coffee trees in 2008/2009.

Decomposition is a dynamic process regulated by decomposer organisms in which structure fragmentation, chemical transformation and synthesis of compounds occur simultaneously. For nutrient release to the soil-plant system adequately, not only the amount of residue should be considered, but also its quality, in order to achieve sustainable cropping systems, besides ensuring soil conservation and productivity (CHACÓN et al., 2011).

Whether the environmental factors remain constant, the decomposition of plant tissues depends mainly on the C/N ratio, lignin, cellulose and hemicellulose content (ESPINDOLA et al., 2006). As previously reported, the present experiment was performed in the rainy season with an average temperature of 20.5 °C, which may have contributed to a fast mass decomposition and N mineralization. However, the decomposition of plant materials does not only depend on environmental factors, but also on the management of the mass-producing plant in relation to fertilization and the cutting season.

TABLE 4 - Equations of the estimates of dry matter decomposition and nitrogen mineralization as a function of time (t), with the respective decomposition constants (k), half-life time (T½) and R^2 values, in the jack bean and hyacinth bean cut in the year 2008-2009 at 60 (Dec 08), 90 (Jan 09) and 120 days (Feb 09) after the planting intercropped with coffee trees.

Legume	Cutting (days)	Equation	K	T½	R^2
		Remaining dry matter (%)			
Jack bean	60	$y = 101.50009e^{(-0.07448t)}$	0.0745	9	$R^2 = 0.95$
	90	$y = 99.36339e^{(-0.02961t)}$	0.0296	23	$R^2 = 0.97$
	120	$y = 108.86759e^{(-0.0287t)}$	0.0287	24	$R^2 = 0.92$
Hyacinth bean	60	$y = 95.68082e^{(-0.0835t)}$	0.0835	8	$R^2 = 0.91$
	90	$y = 96.36374e^{(-0.03455t)}$	0.0345	20	$R^2 = 0.90$
	120	$y = 103.73837e^{(-0.0365t)}$	0.0365	19	$R^2 = 0.92$
		Remaining nitrogen (%)			
Jack bean	60	$y = 93.53913e^{(-0.04058t)}$	0.0406	17	$R^2 = 0.85$
	90	$y = 108.27153e^{(-0.02433t)}$	0.0243	28	$R^2 = 0.85$
	120	$y = 97.59175e^{(-0.01659t)}$	0.0166	42	$R^2 = 0.93$
Hyacinth bean	60	$y = 87.33679e^{(-0.02283t)}$	0.0228	30	$R^2 = 0.70$
	90	$y = 88.83899e^{(-0.02565t)}$	0.0256	27	$R^2 = 0.82$

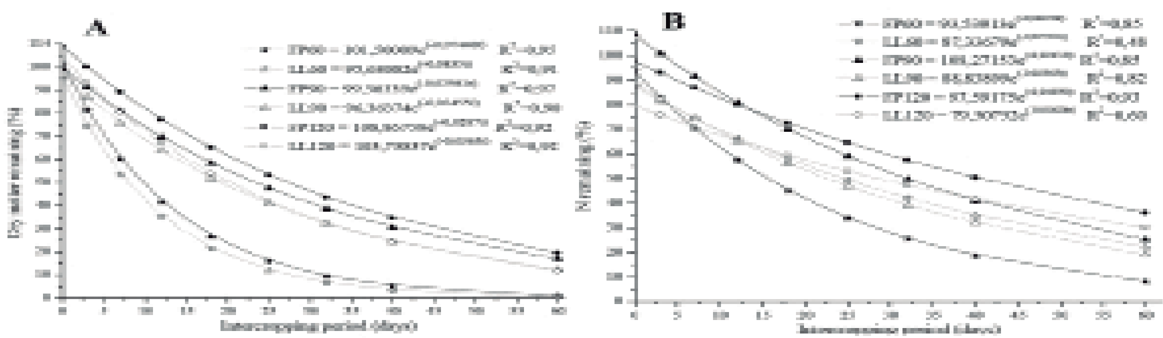

FIGURE 3 - Remaining dry matter (A) remaining nitrogen (B) in the mass of the legumes jack bean (JB) and hyacinth bean (HB) cut at 60 (Dec 08), 90 (Jan 09) or 120 days after sowing (Feb 09) intercropped with coffee trees.

In a study on the N recovery derived from green manure applied to cabbage crop, Aráujo et al. (2011) report that the recovery rate in the soil-plant system varied from 60 to 100%. In addition, this recovery was influenced by the species of green manure, and jack bean was the one that most contributed to the nitrogen nutrition of the cabbage.

The most intense decomposition in the initial phase is also attributed to the water loss and the intense chemical and biochemical oxidation of the less-resistant constituents of the residue, such as hemicellulose, with significant reduction of mass (PEGADO et al., 2008). Thus, the faster decomposition showed by legumes cut at 60 days of planting can also be explained because younger plants are more tender, have lower C:N ratio and lignin content than older plants.

The N mineralization of the jack bean was slower than the hyacinth bean as the legume growth period advanced (Table 4 and Figure 3B). This result can be attributed to the higher precocity of the jack bean, with higher contents of lignin and polyphenols, with shorter cycle and maturation of the plant, presence of pods, thus making the decomposition and the N mineralization slower. The mineralization of the hyacinth bean cut at 60 and 90 DAS was similar to the jack bean, but higher when cut at 120 DAS, probably due to the longer growth cycle evidenced by the absence of flowering up to 120 DAS, and possibly lower lignin content at the beginning of evaluations.

In a study on the brachiaria (*Brachiaria decumbens* Stapf.) biomass decomposition as a nitrogen source in the intercropping with the coffee tree, it was observed that the brachiaria fertilized with nitrogen showed higher decomposition rates of dry matter (DM) at 30, 55 and 85 days after fertilization (DAF) comparatively to residues that did not receive N. Moreover, the decomposition kinetics of the forage biomass for the N rates showed higher rate of decomposition at 30 DAA than at 55 and 85 DAA due to the low lignification of biomass tissues (PEDROSA, 2013). This result shows that the chemical composition of the residue influences the decomposition and N mineralization.

The N mineralization was slower than the mass decomposition, as reported by Oliveira, Gosch and Padovan (2007), These authors reported that the hyacinth bean had a half-life time of 43 days for the mass and 58 days for the nitrogen, in an experiment performed in the state of Tocantins, Brazil. Different results were found by Moreira et al. (2014), in which the nitrogen contained in the legumes was mineralized faster than the mass.

In the jack bean species, the N mineralization was faster than in the hyacinth bean only when cut at 60 DAS. In the other cutting dates (90 and 120 DAS), the T½ was similar for both species. Contrasting results were found by Moreira et al. (2014) in the same year, with T½ (N) valuesof 13, 12 and 16 days for the jack bean and 13, 14 and 17 days for the hyacinth bean, both when cut at 60, 90 and 120 days after planting, although performed in a different site.

Under the conditions of the Viçosa, MG, Brazil, the coffee tree reproductive cycle lasts 224 days and the highest accumulation rates of dry matter, N, P, K, Ca, Mg and S in fruits are observed at the stage of rapid fruit expansion, between 79 and 85 days after anthesis (LAVIOLA et al., 2007). These same authors described that fertilization practices should begin before the onset of the rapid fruit expansion stage, i.e. before 66 days after anthesis, and a higher proportion of macronutrients should be supplied until the end of the rapid expansion stage.

Based on data from Laviola et al. (2007) and in the decomposition data, it can be suggested that the N mineralized in April would be poorly absorbed by the coffee trees. For the Viçosa region, 50% of the nutrients would have to be available to the coffee tree in November, being necessary the cutting of green fertilizers 46 days before, i.e., at the end of September. This practice becomes unviable due to the weather conditions of the region that do not allow planting these legumes with high anticipation.

Therefore, it is recommended that green manures be planted as soon as possible (beginning of the rainfall) and cut 90 days after sowing. Thus, it would be possible to provide part of the nitrogen necessary to the berry formation and maturation phase and for the coffee growth. Therefore, the annual green fertilizers would be used as complementary to the fertilization, either mineral or organic.

When associating the legume decomposition rate, DM yield, N accumulation and mineralization, it could be estimated that two months after cutting, 54,458; 91,018; and 98,066 kg ha^{-1} N would be mineralized from jack bean when cut at 60, 90 and 120 days, respectively (Table 5). For the hyacinth bean, the values would be 15,841; 53,158; and 114,966 kg ha^{-1} N mineralized under the same conditions.

When considering the N contribution (Table 5) of 121.60 kg ha^{-1} by jack bean and 65.68 kg ha^{-1} by the hyacinth bean at 90 days after planting of legumes (January), there would be a mineralization of approximately 55 kg ha^{-1} N by jack bean and 37 kg ha^{-1} N by the hyacinth bean up to 28 days ($T_{1/2}$) after the management, i.e., in February, since the planting occurred in October.

The nutrients not readily released and absorbed by the crop of interest will be stored in the organic matter of the soil and, possibly mineralized and available in the next crop cycle. This reinforces the idea that intercropping green manures between the coffee lines is a viable alternative also to recycle nutrients. In a study on nitrogen fertilization in coffee trees with jack bean biomass, it was related that the higher the volume of residue applied to the soil, the higher the organic matter, Ca^{2+}, SB and CEC contents in the soil (ARAÚJO et al., 2014), strengthening how much green manure can contribute to a better crop development.

TABLE 5 – Estimates of accumulation and mineralization of nitrogen from green manures jack bean and hyacinth bean two months after cutting at 60, 90 and 120 days after sowing.

Legume	Cutting (DAS)	Total N accumulated (kg ha^{-1})	N mineralization (kg ha^{-1})				Total mineralized
			Days after cutting				
			0-15	15-30	30-45	45-60	Up to 60
Jack bean	60	59.32	29.132	13.764	7.488	4.074	54.458
	90	121.60	30.199	27.948	19.402	13.470	91.018
	120	153.39	36.673	25.713	20.049	15.632	98.066
Hyacinth bean	60	20.36	7.734	3.661	2.599	1.846	15.841
	90	65.68	25.966	12.684	8.633	5.876	53.158
	120	164.17	61.893	22.136	17.345	13.591	114.966

4 CONCLUSIONS

The decomposition rate is lower in both green manure species as the cut is delayed in the growing season;

Nitrogen mineralization of the jack bean is slower as the green manure grows for longer periods;

The N mineralization in the jack bean is faster than hyacinth bean only when cut at 60 days, showing similarity at 90 and 120 days.

Green manures should be planted as soon as possible (beginning of the rainfall) and managed 90 days after sowing for greater benefits to the coffee tree.

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