DIVISÃO 2 - PROCESSOS E PROPRIEDADES DO SOLO

Comissão 2.1 - Biologia do solo

INFLUENCE OF MINERAL FERTILIZATION ON EDAPHIC FAUNA IN *Acacia auriculiformis* (A. CUNN) PLANTATIONS[1]

Liliana Parente Ribeiro[2], Emanuela Forestieri Gama-Rodrigues[3], Maria Kellen da Silva Moço[4] & Antonio Carlos Gama-Rodrigues[3]

SUMMARY

Fertilization and/or the accumulation of organic matter from plant residues can influence the composition of soil and litter community. The goal of this study was to evaluate the effects of P and K fertilization on total faunal and nematode faunal composition and richness in plant litter and soil for 360 days in an area reforested with *Acacia auriculiformis* (A. Cunn), located in the municipality of Conceição de Macabu in the State of Rio de Janeiro. For each treatment (fertilized and unfertilized plots), samples of litter and soil (to a depth of 5 cm) were collected and transferred into a Berlese-Tüllgren funnels for the extraction of fauna. Mesofauna and macrofauna were quantified, and the major taxa identified. Nematodes were extracted by centrifugal flotation in sucrose solution and identified according to feeding habits. Density (number of individuals m^{-2}) of total fauna, microphages, social insects and saprophages varied significantly per treatment and sampling time in both litter and soil. The total number of individuals collected was 5,127, and the total number of nematodes 894. Phosphorus and potassium fertilization resulted in an increase in total fauna density and richness in the litter due to an increased abundance of social insects, saprophages and herbivores. In the soil, fertilization increased the saprophage and predator densities. Saprophages were the predominant taxa in the litter, while social insects (Formicidae) prevailed in the soil. Litter nematode populations were favored by mineral fertilization. Bacteriophages were the predominant nematode group in both litter and soil.

Index terms: soil invertebrates, nematode, forest plantations, litter.

---

[1] Part of the Dissertation of the first author, for a postgraduate degree in Plant Production, State University of North Fluminense Darcy Ribeiro - UENF. Received for publication on July 03, 2012 and approved on October 25, 2013.

[2] Doctoral degree in Plant Production, Entomology and Plant Pathology Laboratory, UENF. Av. Alberto Lamego, 2000, Parque Califórnia. CEP 28013-602 Campos dos Goytacazes (RJ), Brazil. E-mail: lailasarlo@yahoo.com.br

[3] Professor of Soil Laboratory, UENF. E-mail: emanuela@uenf.br, tonygama@uenf.br

[4] Doctoral degree in Plant Production, Professor of Fluminense Federal Institute of Education, Science and Technology - IFF. Rua Dr. Siqueira, 273, Parque Dom Bosco. CEP 28030-130 Campos dos Goytacazes (RJ), Brazil. Pronatec scholarship. E-mail: mariakellen@hotmail.com

RESUMO: *INFLUÊNCIA DA ADUBAÇÃO MINERAL NA FAUNA EDÁFICA EM PLANTIOS DE* Acacia auriculiformis *(A. CUNN)*

A adubação ou o acúmulo de matéria orgânica via resíduos vegetais pode influenciar a composição da comunidade da fauna do solo e da serapilheira. O objetivo deste trabalho foi avaliar os efeitos da adubação mineral com P e K sobre a composição e a riqueza da fauna e da nematofauna da serapilheira e do solo em uma área reflorestada com Acacia auriculiformis (A. Cunn), em um período de 360 dias, no município de Conceição de Macabu, RJ. Em cada tratamento (parcela adubada e não adubada), coletaram-se amostras de serapilheira e de solo (até a profundidade de 5 cm), que foram transferidas para funis de Berlese-Tüllgren para a extração da fauna. Meso e macrofauna foram quantificadas e identificadas em nível de grandes grupos taxonômicos. Os nematoides foram extraídos pelo método de flutuação centrífuga em solução de sacarose e identificados de acordo com seus hábitos alimentares. A densidade (número de indivíduos m^{-2}) da fauna total e a de micrófagos, insetos sociais e saprófagos variaram significativamente entre tratamentos e época de coleta, na serapilheira e no solo. O total de indivíduos da fauna foi de 5.127 e de nematoides, 894. Na serapilheira, a adubação com P e K contribuiu para o aumento da densidade e riqueza da fauna total, especificamente de insetos sociais, saprófagos e herbívoros. Já no solo, a adubação promoveu o aumento da densidade de saprófagos e predadores. Os saprófagos predominaram na serapilheira e os insetos sociais (Formicidae), no solo. Os nematoides da serapilheira foram favorecidos pela adubação mineral e os bacteriófagos, o grupo de nematoides dominante tanto na serapilheira quanto no solo.

Termos de indexação: invertebrados do solo, nematoides, plantações florestais, serapilheira.

INTRODUCTION

In the northern/northwestern region of Rio de Janeiro, an extensive history of agricultural and livestock activities has resulted in a reduction in forest cover and a high level of soil degradation. Currently, 80 % of the land use in the region corresponds to pastures in degraded state (Gama-Rodrigues & May, 2001). To decrease the pressure of forest conversion on remnant forest fragments and promote the recovery of degraded soils, techniques that stimulate natural mechanisms of soil restoration are needed (Campello, 1998; Macedo et al., 2008).

The study site is part of a reforestation project that began in December 1998. The project uses tree species, including leguminous trees inoculated with N_2-fixing bacteria and mycorrhizal fungi, as a strategy for soil recovery. The introduction of leguminous forest species has been shown to have positive effects on some soil quality parameters in reforestation projects in degraded areas (Franco et al., 1992; Macedo et al., 2008). In previous studies at the same site, introduced leguminous forest species obtained promising results in terms of soil fertility improvement (Gama-Rodrigues et al., 2008) by contributing to the stability of soil microbial biomass and activity (Zaia et al., 2008) and by increasing C and N reserves available for mineralization (Nunes, 2008). In addition, the leguminous species appeared to increase the number of individuals in different functional guilds in the litter-soil system (Manhães, 2008).

The soil fauna is an important component of forest ecosystems because of its functional role in accelerating the decomposition of organic matter and the transformation of nutrients (Yang & Chen, 2009). Fertilization and/or the accumulation of organic matter from plant residues can influence the composition of the soil community (Brown et al., 2004; Moço et al., 2005, 2009, 2010) by changing the vegetation structure, which in turn results in changes in litter quality and quantity (Wardle et al., 2006).

In forest and agroforestry systems, low rates of soil inversion and constant organic matter input from litterfall contribute to the formation of a diversity of micro habitats that result in a high diversity and density of organisms in the litter-soil system (Moço et al., 2005, 2010; McAdam et al., 2007; Wardle et al., 2006; Laossi et al., 2008). Together with these characteristics, which are inherent to forest systems, the enrichment of the litter layer through fertilization may be an effective method for increasing the activity of the faunal community and optimizing the natural functions of forest and agroforestry ecosystems. However, the effect of mineral fertilization and its influence on edaphic fauna is still controversial. Alves et al. (2008) observed a greater abundance of macrofauna in soils supplied with organic or mineral fertilization, suggesting that the addition of mineral fertilizer resulted in increased plant biomass production and consequently in increased populations of soil organisms, mostly earthworms. However, Sileshi & Mafongoya (2006) observed lower faunal diversity in mineral fertilization treatments. Increases in the quality and quantity of plant residues deposited on the soil have been considered to be beneficial for the abundance and diversity of edaphic fauna (Baretta et al., 2003; Yang et al., 2007; Almeida et al., 2007; Gatiboni et al., 2009).

Furthermore, very few studies have tested fertilization of litter as a management practice for

promoting faunal density and diversity in litter-soil systems. The goal of this study was to evaluate the influence of mineral fertilization on the abundance and diversity of soil organisms, focusing on mesofaunal, macrofaunal and nematode communities in litter and soil, in an area reforested with *Acacia auriculiformis* in the municipality of Conceição de Macabu in the State of Rio de Janeiro (RJ), Brazil.

MATERIAL AND METHODS

Study site

The study was conducted on the Fazenda Carrapeta in Conceição de Macabu, RJ (21º 37' S, 42º 05' W). The site has a predominantly undulating relief with an average slope of approximately 35 cm m^{-1}. The soil is a Yellow-Red Latosol (Hapludox) with a sandy clay loam texture. The regional climate type, Am (Köppen classification), is hot and humid. The mean temperature is 26 ºC, with a mean annual rainfall of 1,400 mm, a rainy season between October and March and a dry season between June and September (Gama-Rodrigues et al., 2008). During the study period, the mean monthly rainfall in the region was 119.2 mm.

In December 1998, the Fazenda Carrapeta joined the project "Cordão de Mata" with the goal of recovering part of its area that had been degraded by careless use of fire and overgrazing for 40 years. An area on the farm was selected for restoration, strategically located to improve the connectivity between the areas of revegetation and remaining forest fragments. This area was revegetated with pure stands of various tree species, including leguminous trees. The leguminous tree seedlings were inoculated with selected strains of atmospheric N_2-fixing bacteria and arbuscular mycorrhizal fungi. The seedlings were planted in 0.20 × 0.20 × 0.20 m holes at a spacing of 3 × 2 m. At the time of planting, 150 g single superphosphate, 50 g dolomitic limestone, and 50 g potassium chloride were applied to the planting furrows (Gama-Rodrigues et al., 2008).

Of all introduced tree species, a species of the genus *Acacia* was selected for this study, due to its rapid vegetative growth. The experimental area consisted of a 1,500 m^2 area with a 10-year-old *Acacia auriculiformis* (A. Cunn.) monoculture stand (as described above). Two treatments, with and without fertilization, were applied on a 36 m^2 plot. In the fertilization treatment, 800 g single superphosphate and 230 g potassium chloride were broadcast over the litter layer.

Evaluation of edaphic fauna

Samples of the litter (all plant residues on the soil surface) and soil (to a depth of 5 cm) were collected from 0.25 × 0.25 m quadrats in each treatment (fertilized and unfertilized plots) at 2-month intervals between March-November 2007 and January-March 2008. Five samples per component (litter and soil) were collected per treatment, i.e., a total of 20 samples per sampling event.

The litter and soil samples were placed in a Berlese-Tüllgren funnel battery, which was completely sealed immediately after the sample transfer. Incandescent light bulbs (25 W) were fixed above the funnels and remained lit for the entire period of extraction (15 days). The heat supplied by the lamps generated a humidity gradient in the samples and caused the organisms to migrate to the bottom of the funnel and drop into an Erlenmeyer flask containing approximately 150 mL of 3 % acetylsalicylic acid. The content of each flask was analyzed separately in Petri dishes under a binocular microscope (Moço et al., 2005). The organisms of the meso- and macrofauna were quantified and the major taxa identified. Organisms of the phyla Mollusca and Annelida were identified up to the class level. Arthropods from the classes Arachnida, Crustacea and Insecta were identified up to the order level. Arthropods of the order Hymenoptera were separated in the family Formicidae and all other Hymenoptera. Holometabola (insects with complete metamorphosis from the immature to adult stage) were separated into larvae and adults. Organisms from the order Acarina were not recorded due to the diversity of functional characteristics within the order and to prevent an underestimation of the remaining fauna groups caused by their large population sizes. The recorded taxa were divided into herbivores (feeding on live plant tissue), microphages (regulators of microbial populations), predators (feeding on other organisms), saprophages (feeding on plant residues), social insects (characterized by their social organization), and omnivores (more than one feeding habit) (Swift et al., 1979; Brown et al., 2006).

The faunal density (number of individuals m^{-2}), richness (number of taxonomic groups identified), Shannon's diversity and Pielou's evenness indices were calculated for each litter and soil sample in both treatments (fertilized and unfertilized plots), as described by Odum (1969).

Evaluation of nematodes

In September and November 2007 and January and March 2008, five composite soil samples (each mixed from five single samples) and 5 L samples were collected from each treatment (fertilized and unfertilized plots). Soil was collected using an auger (down to a depth of 10 cm) and litter samples were collected from a 0.25 × 0.25 m quadrat.

Nematodes were extracted by centrifugal flotation in a sucrose solution. Each sample was sieved through a 20 mesh (841 μm) and then a 500 mesh (25 μm). The resulting liquid was collected in a 100 mL beaker, a minimum of 40 mL of solution was added to achieve the final suspension, and the solution was centrifuged at 2,000 rpm for 5 min. The supernatant was collected, added to the sucrose solution and centrifuged for 1

min at 1,750 rpm. After washing to remove the sucrose solution, 15 mL of the suspension was removed for observation. Five aliquots were used for counting and identification (Jenkins, 1964).

The nematodes were grouped according to the feeding habit (Yeates et al., 1993) as follows: bacteriophages (free-living nematodes that feed on bacteria and contribute to organic matter decomposition), mycophages (feeding on fungi and contributing to organic matter decomposition), phytoparasites (plant parasites) and predators (feeding on other nematodes).

Chemical analysis of litter and soil

Chemical characterization of litter and soil samples was performed for both treatments (fertilized and unfertilized plots) at 2-month intervals over the 12-month study period. The concentrations of K (flame photometry), P - colorimetric determination using ascorbic acid, modified by Braga & Defelipo (1974), and Ca and Mg (atomic absorption spectrophotometry) in the litter samples were determined based on nitric-perchloric acid digestion. For both the litter and soil samples, total N was determined by the Kjeldahl method (Embrapa, 1997; Bataglia et al., 1983), and organic C was determined by oxidation with potassium dichromate in an acid medium (Anderson & Ingram, 1996; Embrapa, 1997). Extractable P and K (Mehlich-1) and exchangeable Ca, Mg and Al (KCl 1 mol L^{-1}) (Defelipo & Ribeiro, 1981) concentrations and pH in water were determined for the soil samples. Total polyphenols in the litter were determined by extraction according to Anderson & Ingram (1996), and lignin and cellulose contents were determined by the acid detergent fiber (ADF) method (van Soest & Wine, 1968).

Statistical analysis

All data were tested for normality (Lilliefors test) and homogeneity of variance (Bartlett test). For the chemical analyses of litter and soil, an analysis of variance (ANOVA) followed by a Duncan test was used to test for significant differences between the means ($p \leq 0.05$).

The data distributions of the faunal diversity parameters (total density, total richness and density of functional groups) and nematode abundance (trophic groups) in litter and soil did not follow a normal distribution. Therefore, non-parametric Wilcoxon and Kruskall-Wallis tests were applied ($p \leq 0.05$). Wilcoxon tests were used for the analyses with two levels of variation: treatment (fertilized and unfertilized plots) and component (soil and litter). Kruskall-Wallis tests were used for the analyses with more than two levels of variation, i.e., the data from the different sampling events. Differences in the Shannon's diversity index were analyzed using t-tests according to Hutcheson (1970). Comparisons of the estimated results were performed using Past software (Hammer et al., 2001).

Statistical analyses were performed using the SAEG application (Sistema de Análises Estatísticas and Genéticas [Statistical and Genetic Analyses System]) version 8.0 (Ribeiro Júnior & De Melo, 2008).

RESULTS AND DISCUSSION

Litter and soil chemical analysis

In general, the application of mineral fertilizer resulted in an increase in mean P and organic C concentrations of soil and litter (Table 1). Mean K concentrations in the litter also increased with fertilization, whereas mean cellulose and lignin content and soil pH decreased. The observed increase in K was expected due to the high rate of K absorption by acacia, which was expected to result in a higher K content in the leaf litter. The observed decrease in cellulose and lignin levels was likely due to an increase in the rate of litter decomposition as a result of nutritional enrichment of the litter through potassium chloride and single superphosphate fertilization, which added Ca and S to the litter in addition to P. The decrease in pH was likely due to the increased decomposition rate, which would promote soil acidification through the production of organic acids and the activity of soil biota.

The other nutrients analyzed in this study showed little variation between treatments. The greatest differences among sampling periods were observed for soil and litter P concentrations, which increased in May, July, September and November in both treatments, but tended to stabilize in January 2008.

Edaphic fauna

In this study, 5,127 individuals of 24 different taxa were identified in the litter + soil system. A larger faunal community was observed in the litter (3,242 individuals). Total fauna density and density of microphages, social insects and saprophages varied significantly between treatments, among sampling times and between components (litter and soil) (Table 2). Predator and herbivore abundance were affected by fertilization treatment and component, but richness and omnivore abundance only by component.

The mean total faunal density and richness (1,621 individuals m^{-2} and 9.6 groups, respectively) were higher in the litter than the soil (943 individuals m^{-2} and 6.3 groups, respectively), regardless of the treatment (fertilized or unfertilized) (Table 3). Faunal density and total richness in the litter increased with fertilization. This result may have been related to the higher organic C concentrations in the fertilized litter (Table 3). In contrast, in the soil, faunal density and total richness were higher in the unfertilized plot (Table 3). The evasion of faunal organisms into the soil of the unfertilized plots may have been caused by

the relatively high cellulose and lignin levels in the litter (Table 1), which may have made the litter material more recalcitrant and less attractive to faunal colonization than the soil. According to Swift et al. (1979), the amount of recalcitrant compounds can affect the palatability of litter for populations of decomposer organisms, thereby negatively affecting faunal density and diversity. In addition, lignin and cellulose are known to be decomposed by specific groups of organisms and may inhibit the population growth of some faunal groups (Tian et al., 1993).

Collembola, which was the only taxon classified as microphage, accounted for 9 % of the total fauna (litter + soil). Social insects in the litter + soil were dominated by the family Formicidae (94 %), which represented 37 % of all recorded organisms (Table 4). Saprophages were the functional group with the highest number of different

Table 1. Chemical analyses of fertilized and unfertilized litter and soil of an *Acacia auriculiformis* plantation

Attribute	Treatment	March	May	July	September	November	January	March	Average
				2007			2008		
					Litter				
Organic C (g kg^{-1})	Fertilized	452 ^{ns}	478	598	480	362	443	433	464 A
	Unfertilized	439 ^{ns}	553	529	375	355	477	404	396 B
Total N (g kg^{-1})	Fertilized	10.9 ab	12.7 a	12.9 a	11.4 ab	9.5 b	10.8 ab	11.6 a	11.4 A
	Unfertilized	11.1 ab	11.5 a	12.9 a	13.3 a	11.1 ab	11.9 a	8.3 b	11. 4 A
P (g kg^{-1})	Fertilized	0.45 bc	0.61 abc	0.66 ab	0.66 ab	0.70 a	0.64 ab	0.41 c	0.59 A
	Unfertilized	0.34 b	0.39 a	0.44 a	0.40 a	0.46 a	0.43 a	0.32 a	0.40 B
K (g kg^{-1})	Fertilized	0.05 bc	0.06 b	0.10 a	0.10 a	0.06 bc	0.05 bc	0.04 c	0.06 A
	Unfertilized	0.02 b	0.04 b	0.07 a	0.07 a	0.04 b	0.03 b	0.03 b	0.04 B
Ca (g kg^{-1})	Fertilized	10.7 ^{ns}	10.1	11.0	10.2	8.6	18.6	10.8	11.4 A
	Unfertilized	12.6 a	12.3 a	12.4 a	12.6 a	12.1 a	12.7 a	7.1 b	10.7 A
Mg (g kg^{-1})	Fertilized	1.07 a	0.79 b	1.01 a	1.01 a	0.97 a	0.78 a	0.92 a	0.94 A
	Unfertilized	1.03 a	1.18 a	1.31 a	1.20 a	1.20 a	1.00 a	0.53 b	1.06 A
Polyphenol (g kg^{-1})	Fertilized	5.0 ab	5.0 ab	6.0 a	4.0 ab	2.0 b	2.0 b	2.0 b	3.6 A
	Unfertilized	4.0 b	4.0 b	9.0 a	8.0 a	4.0 b	3.0 b	1.0 b	4.9 A
Cellulose (g kg^{-1})	Fertilized	145 ab	160 ab	156 ab	126 b	114 b	136 b	197 a	143 B
	Unfertilized	273 a	176 bc	204 b	207 b	221 b	208 b	128 c	199 A
Lignin (g kg^{-1})	Fertilized	583 a	538 ab	511 ab	577 ab	538 ab	538 ab	488 b	540 B
	Unfertilized	526 b	608 b	594 b	546 b	576 b	600 b	746 a	600 A
					Soil				
pH	Fertilized	4.41 ^{ns}	4.54	4.45	4.54	4.46	4.54	4.47	4.49 B
	Unfertilized	4.70 ^{ns}	4.79	4.72	4.66	4.68	4.77	4.72	4.72 A
Organic C (g kg^{-1})	Fertilized	2.98 ^{ns}	3.42	3.08	3.12 a	3.18 a	2.82 a	2.98 a	3.08 A
	Unfertilized	2.58 ^{ns}	2.85	3.04	2.54 a	2.64 a	3.01 a	2.55 a	2.74 B
Total N (%)	Fertilized	0.29 ab	0.32 ab	0.31 ab	0.35 a	0.28 ab	0.25 b	2.98 a	0.30 A
	Unfertilized	0.27 ^{ns}	0.28	0.27	0.26	0.29	0.29	2.55	0.28 A
P (mg dm^{-3})	Fertilized	3.74 d	12.5 b	8.4 c	15.6 a	8.7 c	4.9 d	3.5 d	8.18 A
	Unfertilized	3.99 ^{ns}	3.8	4.0	4.0	3.7	4.2	2.8	3.79 B
K (mg dm^{-3})	Fertilized	51 c	66 bc	74 b	133 a	78 b	59 bc	59 bc	74 A
	Unfertilized	51 c	63 bc	82 ab	98 a	82 ab	55 c	51 a	70 A
Ca (cmol$_c$ dm^{-3})	Fertilized	2.90 ^{ns}	3.6	3.4	3.0	2.6	2.5	2.7	2.95 A
	Unfertilized	3.0 ^{ns}	3.1	3.1	2.9	2.7	3.1	2.5	2.92 A
Mg (cmol$_c$ dm^{-3})	Fertilized	1.0 ^{ns}	1.0	1.1	1.0	0.9	0.8	0.9	0.95 A
	Unfertilized	1.0 ^{ns}	0.9	1.0	0.9	0.9	0.9	0.8	0.92 A
Al (cmol$_c$ dm^{-3})	Fertilized	0.2 ab	0.1 a	0.2 ab	0.2 ab	0.2 ab	0.2 b	0.2 ab	0.22 A
	Unfertilized	0.3 a	0.2 a	0.2 a	0.2 a	0.2 a	0.2 a	0.2 b	0.16 B

Values followed by the same letter(s) (row), comparing sampling time, within each treatment or by the same capital letter(s) (column), comparing treatments, are not significantly different according to the Duncan test (p=0.05); ns: not significant.

taxonomic groups (10 groups in litter as well as soil) (Table 4). Isopoda, Symphyla and Diptera (larvae) predominated in the saprophage group in both litter (89 %) and soil (93 %). The most abundant predators in the litter were Araneae (63 %), and the most abundant predators in the soil Chilopoda (56 %). The most abundant group in the omnivore category was Coleoptera (adults) in both litter (51 %) and soil (61 %), and the most abundant herbivore was Thysanoptera in both litter (50 %) and soil (31 %) (Table 4).

Table 2. Wilcoxon(1) and Kruskal-Wallis(2) tests related to the effects of fertilization, sampling time and sampled material on density, richness of faunal groups and functional groups of soil and litter fauna

	Effect of		
	Fertilization	**Sampling time**	**Sampled material**
D.f.	1	6	1
Density	0.61*	19.52**	3.72*
Richness	0.28^{ns}	9.68^{ns}	6.48^{*}
Microbial grazer	1.49*	22.56**	1.19*
Social insect	0.65*	16.07*	4.05*
Saprophagous	1.67*	19.76*	7.56*
Predador	0.53*	12.20^{ns}	2.90*
Omnivor	0.30^{ns}	7.14^{ns}	0.83*
Herbivor	0.49*	3.50^{ns}	7.64*

D.f.: degree of freedom; * and ** significant at 5 and 1 %, respectively; ns: not significant.

Social insects (Formicidae) were the dominant functional group in the soil, accounting for 98 % of the organisms. Formicidae is one of the most important edaphic fauna taxa in tropical regions due to its abundance and diversity (Pellens & Garay, 2000; Silva & Silvestre, 2004; Moço et al., 2005). Formicidae has been observed to be the most abundant group in areas where leguminous trees are intercropped in pastures (Dias et al., 2006). The most abundant functional group in the litter was the saprophages (58 %), mainly due to the high abundance of Isopoda (78 %). Saprophages play a key role in litter decomposition. In addition to releasing N in the decomposition process, they may make other nutrients available, such as K, Mg, and Ca (Kayang et al., 1994; Förster et al., 2006).

The remaining functional groups in the litter can be ranked by abundance as follows: social insects (24 %) > microphages (9 %) > herbivores (4 %) > omnivores (3 %) > predators (2 %). In the soil, the order of abundance was: social insects (68 %) >

Table 3. Density and Richness of litter and soil fauna of an *Acacia auriculiformis* plantation, fertilized and unfertilized

Time	Litter		Soil		Average
	Fertilized	**Unfertilized**	**Fertilized**	**Unfertilized**	
	Density individual m^{-2} - ($\bar{x}$ ± SE)(1)				
March 2007	1533 ± 401	1213 ± 219	531 ± 122	957 ± 215	1059 ab
May 2007	2576 ± 906	1114 ± 301	1066 ± 150	672 ± 200	1357 a
July 2007	1264 ± 284	720 ± 229	861 ± 257	1043 ± 478	972 ab
September 2007	2013 ± 471	2710 ± 885	797 ± 117	1754 ± 695	1818 a
November 2007	3718 ± 1365	2586 ± 656	448 ± 80	736 ± 126	1872 a
January 2008	1117 ± 535	742 ± 306	643 ± 113	448 ± 109	734 b
March 2008	694 ± 217	726 ± 425	598 ± 193	2646 ± 2124	1166 ab
Average	1845 A *a*	1402 B *a*	706 B *b*	1179 A *b*	
	Richness - Groups of fauna ($\bar{x}$ ± SE)(1)				
March 2007	9.6 ± 0.51	11.2 ± 1.46	5.6 ± 1.12	7.6 ± 1.69	8.5^{ns}
May 2007	11.0 ± 1.52	8.6 ± 1.21	8.2 ± 1.32	7.4 ± 1.29	8.8
July 2007	8.4 ± 0.51	7.2 ± 0.92	4.8 ± 0.86	6.8 ± 1.24	6.8
September 2007	11.4 ± 0.68	11.2 ± 1.39	6.4 ± 0.51	6.8 ± 0.86	8.9
November 2007	10.0 ± 0.77	11.8 ± 0.77	5.6 ± 0.51	6.4 ± 0.40	8.4
January 2008	8.2 ± 1.74	8.6 ± 0.87	6.6 ± 0.68	5.8 ± 1.16	7.3
March 2008	9.6 ± 1.17	7.6 ± 2.18	4.8 ± 0.49	6.4 ± 0.75	7.1
Average	9.7 A *a*	9.5 B *a*	6.0 B *b*	6.7 A *b*	

(1) Standard error of mean. Values followed by the same capital letter(s) within each material sampled (litter or soil) comparing treatments (fertilized or unfertilized), are not significantly different according to the Wilcoxon test (p=0.05). Italic letters comparing material sampled in each treatment are not significantly different according to the Wilcoxon test (p=0.05); Values followed by the same letter(s) within column are not significantly different according to the Kruskal-Wallis test (p=0.05); ns: not significant.

saprophages (14 %) > microphages (10 %) > omnivores (5 %) > predators (2 %) > herbivores (1 %) (Table 4).

In the litter, social insects, saprophages and herbivores occurred at higher densities in the fertilized plot, while predators occurred at a higher density in the unfertilized plot (Table 4). The variation in the response of these different functional groups to fertilization was likely due to the feeding habits of the organisms. For social insects, saprophages and herbivores, the enrichment of the litter due to fertilization (increased C, P and K concentrations and decreased cellulose and lignin content) favored rapid reproduction of these organisms in the litter layer, which is a food source for these faunal groups.

In the soil, saprophages occurred at a higher density in the fertilized plot, while microphages, social insects, predators, and herbivores occurred at higher densities in the unfertilized plot (Table 4). Increased concentrations of P and organic C in the soil due to fertilization may have favored the microbial colonization and decomposition of plant residues, thus increasing food availability for saprophages, which feed on decomposing organic matter.

The fertilization of pasture soils with P and K has been observed to increase the biomass of Collembola

Table 4. Density of litter and of soil faunal groups under *Acacia auriculiformis* plantation, fertilized and unfertilized

Faunal group	Litter				Soil			
	Fertilized		Unfertilized		Fertilized		Unfertilized	
	Individual m^{-2}	%	Individual m^{-2}	%	Individual m^{-2}	%	Individual m^{-2}	%
Microbial grazers	141 a	7.6	153 a	10.9	69 b	9.8	114 a	9.7
Collembola	141 ± 373	7.6	153 ± 90	10.9	69 ± 36	9.8	114 ± 54	9.7
Social insect	400 a	21.7	361 b	25.8	412 b	58.4	872 a	74.0
Formicidae	340 ± 342	18.4	313 ± 192	22.4	404 ± 119	57.2	860 ± 831	72.9
Formicidae (larvae)	3 ± 8	0.2	0	0	0	0	0	0
Isoptera	57 ± 98	3.1	49 ± 102	3.5	8 ± 10	1.2	12 ± 20	1.0
Saprophagous	1150 a	62.4	735 b	52.5	149 a	21.1	120 b	10.2
Psocoptera	29 ± 28	1.6	51± 53	3.7	9 ± 18	1.3	1± 2	0.1
Isopoda	914 ± 432	49.6	556 ± 296	39.8	111 ± 48	15.8	74 ± 47	6.2
Diplopoda	9 ± 11	0.5	9 ± 10	0.7	9 ± 11	1.3	7 ± 8	0.6
Blattodea	15 ± 9	0.8	15 ±9	1.0	0	0	3 ± 3	0.2
Symphyla	101 ± 107	5.5	41 ± 31	2.9	14 ± 10	1.9	28 ± 18	2.4
Gastropoda	0	0	0	0	0	0	0	0
Oligochaeta	2 ± 4	0.1	0	0	0	0	0	0
Diptera (larvae)	77 ± 62	4.2	60 ±41	4.3	4 ± 6	0.5	7 ± 7	0.6
Protura	0	0	0	0	0	0	0	0
Pauropoda	3 ± 3	0.2	4 ± 5	0.3	2 ± 3	0.3	1 ± 2	0.1
Predators	39 b	2.1	40 a	3.0	15 b	2.2	21 a	1.7
Diplura	2 ± 3	0.1	1 ± 2	0.1	0.5 ± 1	0.1	0	0
Dermaptera	0	0	0	0	0	0	0	0
Araneae	27 ± 14	1.5	23 ± 19	1.7	6 ± 5	0.8	10 ± 6	0.8
Chilopoda	10 ± 6	0.5	16 ± 12	1.1	8 ± 6	1.1	12 ± 9	1.0
Pseudoescorpionida	0	0	0	0	1 ± 2	0.2	0	0
Herbivores	60 a	3.3	54 b	3.9	5 b	0.7	8 a	0.7
Hemiptera	1 ± 2	0.0	5 ± 5	0.3	1 ± 2	0.2	0.5 ±1	0.0
Thysanoptera	29 ± 18	1.6	28 ± 24	2.0	2 ± 4	0.3	2 ± 2	0.2
Orthoptera	20 ± 15	1.1	18 ± 11	1.3	1 ± 2	0.1	1 ± 2	0.1
Lepidoptera (larvae)	10 ± 8	0.5	3 ± 3	0.2	0.5 ± 1	0.1	5 ± 9	0.4
Omnivores	53 a	2.9	54 a	3.9	55 a	7.8	44 a	5.3
Diptera (adult)	7 ± 7	0.4	9 ± 9	0.6	1 ± 2	0.1	1 ± 3	0.1
Coleoptera (adult)	25 ± 18	1.4	30 ± 16	2.1	36 ± 20	5	24 ± 10	2.1
Coleoptera (larvae)	21 ± 13	1.1	14 ± 10	1.0	19 ± 11	2.7	18 ± 12	1.6
Hymenoptera	0	0	1 ± 2	0.1	0	0	0	0
Total	1843 ± 773	100.0	1399 ± 575	100.0	706 ± 169	100.0	1179 ± 855	100.0

and enchytraeids, as well as the diversity and evenness of the faunal communities (van der Wal et al., 2009). Another study showed that fertilization with N, P, K and micronutrients in rainforests resulted in higher litter accumulation and an increased relative abundance of arthropods due to the increases in litter (Yang et al., 2007).

The Shannon's diversity index did not vary significantly between treatments (fertilized and unfertilized plots), when compared with Hutcheson t-tests (Table 5). The Shannon's index was higher for litter than for soil, but only in the unfertilized plot (H' = 2.02 vs. 0.60; df = 1362.3; t = 30.62; p<0.0001). The Pielou's evenness index did not vary between treatments (fertilized and unfertilized plot) or components (litter and soil). For both indices, the observed variation among sampling events was random. Similar variation among sampling events was observed for total density and richness (Table 3).

These results suggest that fertilization favored certain groups of litter organisms and may have induced the migration of other organisms from the soil into the litter as a result of the improved nutritional quality of the litter and increased soil acidity (Table 1) .

Nematode fauna

Fertilization treatment and sampling event both had a significant effect on the abundance of bacteriophage and predator nematodes in both litter and soil and on phytoparasites in the litter. On the soil phytoparasites and the litter as well as soil microphages, the fertilization treatment had a significant effect, but not the sampling time (Table 6). Nematodes were significantly more abundant in the litter of the fertilized plot than the unfertilized plot, but there was no difference between treatments in nematodes in the soil (Table 7). Similarly to the results for the overall faunal community, no evident trend in nematode abundance was observed when comparing the different sampling events.

A total of 894 mostly litter-inhabiting nematodes were identified in the experiment. Bacteriophages were the dominant group in the litter (65 %), followed by predators (21 %) > mycophages = phytoparasites (7 %). Bacteriophages were also the dominant group in the soil (66 %), followed by phytoparasites (15 %) > predators (13 %) > microphages (6 %) (Table 7). These results show the importance of bacteriophage and predator colonization of the litter, which probably occurred because of the low frequency of soil management activities in the study area (Torres et al., 2006). Bacteriophages are free-living organisms that feed indiscriminately on beneficial, saprophytic and pathogenic bacteria. Large populations of these organisms can therefore indicate high bacterial activity due to increased amounts of mineralizable soil N (Mattos et al., 2006). The higher number of phytoparasites observed in the soil in this study may be associated with parasitism of plant roots.

The results of this study suggest that mineral fertilization of plant litter with P and K is beneficial for the faunal community in general. Future studies that integrate soil faunal analyses with decomposition, nutrient cycling rates and litter nutrient content in stands of *Acacia* and other forest species can expand the knowledge about the functioning of forest ecosystems and agroforestry production systems.

CONCLUSIONS

1. Phosphorus and potassium mineral fertilization of *Acacia auriculiformis* resulted in an increase in the density and richness of faunal communities in plant litter. More specifically, social insects, saprophages (mainly Isopoda) and herbivores appeared to benefit from fertilization. In the soil, fertilization resulted in an increase in saprophage and predator (mainly Chilopoda) density.

Table 5. Shannon[(1)] and Pielou[(2)] index of faunal groups in litter and soil of an *Acacia auriculiformis* plantation, fertilized and unfertilized

Attribute	Treatment	March	May	July	September	November	January	March	Average
		2007					2008		
		Shannon index[(1)]							
Litter	Fertilized	1.60	1.80	1.51	1.43	1.39	1.71	1.84	1.61
	Unfertilized	1.73	1.85	1.63	1.95	1.54	1.82	2.02	1.79
Soil	Fertilized	1.36	1.42	1.23	1.53	1.32	1.72	1.12	1.39
	Unfertilized	1.22	1.13	1.22	0.97	1.45	1.70	0.60	1.18
		Pielou index[(2)]							
Litter	Fertilized	0.59	0.62	0.53	0.60	0.55	0.68	0.79	0.62
	Unfertilized	0.69	0.66	0.74	0.69	0.62	0.74	0.56	0.67
Soil	Fertilized	0.59	0.68	0.70	0.73	0.70	0.69	0.74	0.69
	Unfertilized	0.52	0.53	0.62	0.44	0.73	0.75	0.61	0.60

Values followed by the same letter(s) (row), comparing sampling time, within each treatment or by the same capital letter(s) (column), comparing treatments are not significantly different according to the Duncan test (p=0.05); ns: not significant.

Table 6. Wilcoxon[(1)] and Kruskal-Wallis[(2)] tests of the effects of fertilization and sampling time on litter and soil nematode groups

		D.f.	Bacteriophage	Mycophage	Phytoparasite	Predator
Litter	Fertilization[(1)]	1	1,10*	0,20*	0,26*	0,49*
	Sampling time[(2)]	6	12,73*	1,5 [ns]	0,01*	15,21*
Soil	Fertilization[(1)]	1	0,81*	1,09*	1,03*	0,55*
	Sampling time[(2)]	6	25,42*	0,90 [ns]	2,48 [ns]	20,27*

D.f.: degree of freedom.

Table 7. Number of nematode groups on fertilized and unfertilized litter and soil of an *Acacia auriculiformis* plantation

		Number of nematode group		
		Fertilized	Unfertilized	Average
			Litter	
November 2007	Bacteriophage	11 ± 7*b*	23 ± 9*a*	17 b
	Mycophage	8 ± 5*a*	10 ± 5*a*	9 a
	Phytoparasite	0 ± 0*b*	4 ± 2*a*	2 a
	Predator	0 ± 0*a*	0 ± 0*a*	0b
January 2008	Bacteriophage	140 ± 41*a*	99 ± 52*b*	120 a
	Mycophage	7 ± 4*a*	2 ± 2 *b*	4 a
	Phytoparasite	21 ± 11*a*	6 ± 2*b*	13 a
	Predator	35 ± 9*a*	37 ± 16*a*	38 a
March 2008	Bacteriophage	80 ± 14*a*	52 ± 10*b*	66 a
	Mycophage	5 ± 3*b*	13 ± 6*a*	9 a
	Phytoparasite	5 ± 4*a*	5 ± 2*a*	5 a
	Predator	32 ± 8*a*	25 ± 8*b*	28 a
Average[(1)]		116 A	91 B	
			Soil	
September 2007	Bacteriophage	10 ± 3*a*	4 ± 1*b*	7 b
	Mycophage	2 ± 2*a*	1 ± 1*b*	1 a
	Phytoparasite	7 ± 4*a*	1 ± 0*b*	4 a
	Predator	1 ± 0*a*	1 ± 1*a*	1 b
November 2007	Bacteriophage	20 ± 2*a*	25 ± 6*a*	23 a
	Mycophage	3 ± 1*a*	1 ± 0*b*	2 a
	Phytoparasite	6 ± 3*a*	4 ± 1*b*	5 a
	Predator	5 ± 1*a*	5 ± 1*a*	4 ab
January 2008	Bacteriophage	16 ± 3*a*	17 ± 3*a*	17 b
	Mycophage	2 ± 1*a*	2 ± 1*a*	2 a
	Phytoparasite	6 ± 2*a*	5 ± 2*a*	7 a
	Predator	4 ± 1*a*	3 ± 1*a*	5 a
March 2008	Bacteriophage	36 ± 5*b*	54 ± 19*a*	45a
	Mycophage	3 ± 2*a*	1 ±1*b*	2a
	Phytoparasite	7 ± 5*a*	6 ± 2*b*	7a
	Predator	8 ± 3*a*	8 ± 2*a*	8a
Average[(1)]		34A	36A	

[(1)] Values followed by the same capital letter(s) comparing treatments (fertilized or unfertilized), are not significantly different according to the Wilcoxon test (p=0.05). Italic letter(s) within sampling time and nematode group comparing treatments (fertilized or unfertilized) are not significantly different according to the Wilcoxon test (p=0.05). Values followed by the same letter(s) in a (column), within sampling time comparing nematode groups, are not significantly different according to the Kruskal-Wallis test (p=0.05).

2. Of the different functional groups examined in this study, saprophages (mainly Isopoda) were the predominant group in plant litter, while social insects (Formicidae) prevailed in the soil.

3. Nematodes in the litter were favored by fertilization. Bacteriophages were the predominant nematode group in both litter and soil.

ACKNOWLEDGEMENTS

The authors are indebted to FAPERJ for financial support to conduct the project; CAPES for the scholarship to the first author; they wish to thank Prof. Geraldo Gravina and Dr. Gilson Souza Filho for their assistance with statistical analysis; and Katia Regina do Rosário Nascimento Sales, Vanilda Ribeiro de Souza and Ederaldo Azeredo da Silva of Soil Laboratory, North Fluminense State University for technical support in soil sample collection and analysis.

LITERATURE CITED

ALMEIDA, H.C.; ALMEIDA, D.A.; ALVES, M.V.; SCHNEIDER, J.; MAFRA, A.L. & BERTOL, I. Propriedades químicas e fauna do solo influenciadas pela calagem em sistema semeadura direta. Ci. Rural, 37:1462-1465, 2007.

ALVES, M.V.; SANTOS, J.C.; GOIS, D.T.; ALBERTON, J.V. & BARETTA, D. Macrofauna do solo influenciada pelo uso de fertilizantes químicos e dejetos de suínos no oeste do Estado de Santa Catarina. R. Bras. Ci. Solo, 32:589-598, 2008.

ANDERSON, J.D. & INGRAM, J.S.I. Tropical soil biology and fertility: A handbook of methods. 2.ed. Wallingford, CAB International, 1996. 171p.

BARETTA, D.; SANTOS, J.C.P.; MAFRA, A.L.; WILDNER, L.P. & MIQUELLUTI, D.J. Fauna edáfica avaliada por armadilhas de catação manual afetada pelo manejo do solo na região oeste catarinense. R. Ci. Agrovet., 2:97-106, 2003.

BATAGLIA, O.C.; FURLANI, A.M.C.; TEIXEIRA, J.P.F.; FURLANI, P.R. & GALLO, J.R. Métodos de análise química de plantas. Campinas, Instituto Agronômico de Campinas, 1983. 48p. (Boletim Técnico, 78)

BRAGA, J.M. & DEFELIPO, B.V. Determinação espectrofotométrica de fósforo em extrato de solo e material vegetal. R. Ceres, 21:73-85, 1974.

BROWN, G.G.; MORENO, A.G.; BAROIS, I.; FRAGOSO, C.; ROJAS P. & HERNÁNDEZ, B. Soil macrofauna in SE Mexican pastures and the effect of conversion from native to introduced pastures. Agric. Ecosyst. Environ., 103:313-327, 2004.

BROWN, G.G.; RÖMBKE, J.; HÖFER, H.; VERHAAGH, M.; SAUTTER, K.D. & SANTANA, D.L.Q. Biodiversity and function of soil animals in Brazilian agroforestry systems. In: GAMA-RODRIGUES, A.C.; BARROS, N.F.; GAMA-RODRIGUES, E.F.; FREITAS, M.S.M.; VIANA, A.P.; JASMIN, J.M.; MARCIANO, C.R. & CARNEIRO, J.G.A., eds. Sistemas Agroflorestais: Bases científicas para o desenvolvimento sustentável. Campos dos Goytacazes, UENF, 2006. p.217-242.

CAMPELLO, E.F.C. Sucessão vegetal na recuperação de áreas degradadas. In: DIAS, L.E. & GRIFFITH, J.J., eds. Recuperação de áreas degradadas. Viçosa, MG, Universidade Federal de Viçosa, 1998. 196p.

DEFELIPO, B.V. & RIBEIRO, A.C. Análise química do solo. Viçosa, MG, Universidade Federal de Viçosa, 1981. 17p. (Boletim de Extensão, 29)

DIAS, P.F.; SOUTO, S.M.; CORREIA, M.E.F.; ROCHA, G.P.; MOREIRA, J.F.; RODRIGUES, K.M. & FRANCO, A. Árvores fixadoras de nitrogênio e macrofauna do solo em pastagem de híbrido de Digitaria. Pesq. Agropec. Bras., 41:1015-1021, 2006.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA. Central Nacional de Pesquisa de Solo. Manual de métodos de análise de solos. 2.ed. Rio de Janeiro, 1997. 212p.

FÖRSTER, B.; MUROYA, K. & GARCIA, M. Plant growth and microbial activity in a tropical soil amended with faecal pellets from millipedes and woodlice. Pedobiologia, 50:281-290, 2006.

FRANCO, A.A.; CAMPELLO, E.F.C.; SILVA, E.M.R. & FARIA, S.M. Revegetação de solos degradados. Seropédica, Embrapa/Centro Nacional de Pesquisa em Agrobiologia, 1992. 9p. (Comunicado Técnico, 9)

GAMA-RODRIGUES, A.C. & MAY, P. SAF e o planejamento do uso da terra: Experiência na região Norte Fluminense-RJ. In: CONGRESSO BRASILEIRO DE SISTEMAS AGROFLORESTAIS, 3., Manaus, 2001. Anais... Manaus, Sistemas agroflorestais: Manejando a biodiversidade e compondo a paisagem rural/Sociedade Brasileira de Sistemas Agroflorestais, 2001. p.130-145.

GAMA-RODRIGUES, E.F.; GAMA-RODRIGUES, A.C.; PAULINO, G.M. & FRANCO, A.A. Atributos químicos e microbianos de solos sob diferentes coberturas vegetais no norte do Estado do Rio de Janeiro. R. Bras. Ci. Solo, 32:1521-1530, 2008.

JENKINS, W.R. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Reporter, 48:692, 1964.

KAYANG, H.; SHARMA, G.D. & MISHRA, R.R. Effect of isopod grazing (*Burmoniscus* sp.) upon microbes and nutrient release from decomposing leaf litter of *Alnus nepalensis* D. Don. Eur. J. Soil Biol., 30:11-15, 1994.

GATIBONI, L.C.; COIMBRA, J.L.M.; WILDNER, L.P. & DENARDIN, R.B.N. Modificações na fauna edáfica durante a decomposição da palhada de centeio e aveia preta, em sistema plantio direto. R. Biot., 22:45-53, 2009.

HAMMER, O.; HARPER, D.A.T. & RYAN, P.D. PAST: Paleontological statistics: Software package for education and data analysis. Palaeontol. Electr., 4:9, 2001. Available at: <http://palaeo-electronica.org/2001_1/past/issue1_01.htm>. Accessed: Jan. 16, 2013.

HUTCHESON, K. A test for comparing diversities based on the Shannon formula. J. Theor. Biol., 29:151-154, 1970.

LAOSSI, K.R.; BAROT, S.; CARVALHO, D.; DESJARDINS, T.; LAVELLE, P.; MARTINS, M.; MITJA, D.; RENDEIRO, A.C.; ROUSSEAU, G.; SARRAZINA, M.; VELASQUEZ, E. & GRIMALDI, M. Effects of plant diversity on plant biomass production and soil macrofauna in Amazonian pastures. Pedobiologia, 51:397-407, 2008.

MACEDO, M.O.; RESENDE, A.S.; GARCIA, P.C.; BODDEY, R.M.; JANTALIA C.P.; URQUIAGA, S.; CAMPELLO, E.F.C. & FRANCO, A.A. Changes in soil C and N stocks and nutrient dynamics 13 years after recovery of degraded land using leguminous nitrogen-fixing trees. For. Ecol. Manage., 255:1516-1524, 2008.

McADAM, J.H.; SIBBALD, A.R.; TEKLEHAIMANOT, Z. & EASON, W.R. Developing silvopastoral systems and their effects on diversity of fauna. Agrofor. Syst., 70:81-89, 2007.

MANHÃES, C.M.C. Meso e macrofauna do solo e da serapilheira de diferentes coberturas vegetais no norte do estado do Rio de Janeiro, Brasil. Campos dos Goytacazes, Universidade estadual do Norte Fluminense Darcy Ribeiro, Curso de Agronomia, Centro de Ciências e Tecnologias Agropecuárias, 2008. 40p. (Trabalho de Conclusão de Curso)

MATTOS, J.K.A.; HUANG S.P. & PIMENTEL, C.M.M. Grupos tróficos da comunidade de nematoides do solo em oito sistemas de uso da terra nos Cerrados do Brasil Central. Nematol. Bras., 30:267-273, 2006.

MOÇO, M.K.S.; GAMA-RODRIGUES, E.F.; GAMA-RODRIGUES, A.C. & CORREIA, M.E.F. Caracterização da fauna edáfica em diferentes coberturas vegetais na região Norte Fluminense. R. Bras. Ci. Solo, 29:555-564, 2005.

MOÇO, M.K.S.; GAMA-RODRIGUES, E.F.; GAMA-RODRIGUES, A.C.; MACHADO, R.C.R. & BALIGAR, V.C. Soil and litter fauna of cacao agroforestry systems in Bahia, Brazil. Agrofor. Syst., 76:127-138, 2009.

MOÇO, M.K.S.; GAMA-RODRIGUES, E.F.; GAMA-RODRIGUES, A.C.; MACHADO, R.C.R. & BALIGAR, V.C. Relationships between invertebrate communities, litter quality and soil attributes under different agroforestry systems in the south of Bahia, Brazil. Appl. Soil Ecol., 46:347-354, 2010.

NUNES, D.A.D. Mineralização de C e N em solos sob diferentes coberturas vegetais Campos dos Goytacazes, Universidade estadual do Norte Fluminense Darcy Ribeiro, Curso de Agronomia, Centro de Ciências e Tecnologias Agropecuárias, 2008. 48p. (Trabalho de Conclusão de Curso)

ODUM, E.P. The strategy of ecosystem development. Science, 164:262-270, 1969.

PELLENS, R. & GARAY, I. Edaphic macroarthopod communities in fast-growing plantations of *Eucalyptus grandis* Hill ex Maid (Myrtaceae) and *Acacia mangium* Wild (Leguminosae) in Brazil. Eur. J. Soil Biol., 35:77-89, 2000.

RIBEIRO JÚNIOR, J.I. & DE MELO, A.L.P. Guia prático para utilização do SAEG -Sistema de Análises Estatísticas e Genéticas, Versão 8.0. Viçosa, MG, Universidade Federal de Viçosa, 2008.

SILESHI, G. & MAFONGOYA, P.L. Long-term effects of improved legume fallows on soil invertebrate macrofauna and maize yield in eastern Zambia. Agric. Ecosyst. Environ., 115:69-78, 2006.

SILVA, R.R. & SILVESTRE, R. Riqueza da fauna de formigas (Hymenoptera: Formicidae) que habita as camadas superficiais do solo em Seara, Santa Catarina. Papéis Avulsos Zool., 44:1-11, 2004.

SWIFT, M.J.; HEAL, O.W. & ANDERSON, J.M., eds. Decomposition in terrestrial ecosystems. Oxford, Blackwell Scientific Publications, 1979. 372p.

TIAN, G.; BRUSSARD, L. & KANG, B.T. Biological effects of plant residues with contrasting chemical compositions under humid tropical conditions: effects on soil fauna. Soil Biol. Biochem, 25:731-737, 1993.

TORRES, G.R.C.; PEDROSA, E.M.R.; MONTENEGRO, A.A.A.; MICHEREFF, S.J. & MOURA, R.M. Aspectos ecológicos de comunidade de nematoides associada a cultivo de *Cucumis melo* no Rio Grande do Norte. Nematol. Bras., 30:1-9, 2006.

van der WAL, A.; GEERTS, R.H.E.M.; KOREVAAR, H.; SCHOUTEN, A.J.; JAGERS OP AKKERHUIS, G.A.J.M.; RUTGERS, M. &MULDER, C. Dissimilar response of plant and soil biota communities to long-term nutrient addition in grasslands. Biol. Fert. Soil, 45:663-667, 2009.

van SOEST, P. & WINE, R.H. Development of a comprehensive system of feed analysis and its applications to forages. J. Assoc. Official Agron. Chem., 51:780-785, 1968.

WARDLE, D.S.; YEATES, G.W.; BARKER, G.M. & BONNER, K.I. The influence of plant litter diversity on decomposer abundance and diversity. Soil Biol. Biochem., **38:1**052-1062, 2006.

YANG, X. & CHEN, J. Plant litter quality influences the contribution of soil fauna to litter decomposition in humid tropical forests, southwestern China. Soil Biol. Biochem., 41:910-918, 2009.

YANG, X.; WARREN, M. & ZOU, X. Fertilization responses of soil litter fauna and litter quantity, quality, and turnover in low and high elevation forests of Puerto Rico. Appl. Soil Ecol., 37:63-71, 2007.

YEATES, G.W.; BONGERS, T.; DE GOEDE, R.G.M.; FRECKMAN, D.W. & GEORGIEVA, S.S. Feeding habits in nematode families and genera - an outline for soil ecologists. J. Nematol., 25:315-331, 1993.

ZAIA, F.C.; GAMA-RODRIGUES A.C. & GAMA-RODRIGUES, E.F. Formas de fósforo no solo sob leguminosas florestais, floresta secundária e pastagem no norte fluminense. R. Bras. Ci. Solo, 32:1191-1197, 2008.