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Nutrients in litter of four eucalyptus clones under an Integrated Crop-Livestock-Forest System (CLFS)[1]

Amanda Prudente Velozo[2]; Abílio Rodrigues Pacheco[3]; Francine Neves Calil[4]; Carlos de Melo Silva-Neto[5]

Abstract: The objective of this study was to evaluate the biomass production and nutrient stock in the litter of a plantation with four eucalyptus clones (AEC-2034 ((*Eucalyptus camaldulensis* x *E. grandis*) x *E. urophylla*)), AEC-2111 (*E. urophylla* x (*E. camaldulensis* x *E. grandis*)), AEC-007 (*E. toreliana* x *E. citriodora*) and AEC-0043 (*E. citriodora* x *E. toreliana*)) at four and a half years under an integrated crop-livestock-forest system (CLFS) in Inaciolândia, Goiás, Brazil. A template of an area of 0.0625 m² was used for the litter collection (leaves, branches, bark and miscellaneous). Thus, 20 litter samples were collected at random from each clone, totaling 80 samples. All of the material was processed in the laboratory through drying, weighing and grinding to determine biomass and analyze the nutritional content. The results obtained were an accumulation in the average total above ground biomass production estimated at 6.07 Mg ha^{-1} for the AEC-2034 clone, 5.20 Mg ha^{-1} for the AEC-2111 clone, 3.41 Mg ha^{-1} 1 for the AEC-007 clone and 3.23 Mg ha^{-1} for the AEC-0043 clone. The leaf component showed the highest total accumulation in all clones. Nitrogen (N) was the element which presented the highest accumulation in the litter for all clones. The greatest accumulation of litter biomass occurred for the AEC-2034 clone, and the most representative component was leaves. The AEC-2034 clone showed the highest nutrient stock in the litter and the AEC-0043 clone presented the lowest stock. Nitrogen (N) was the macronutrient with the highest accumulation in the evaluated components, and iron (Fe) was the micronutrient. Based on litter and nutrient return, the most suitable clone in the CLFS system in this region is the AEC-2034 clone.

Keywords: Integrated production system; Sustainability; Nutrient cycling

Nutrientes na serapilheira acumulada em quatro clones de eucalipto em sistema de Integração Lavoura-Pecuária-Floresta (ILPF)

Resumo: O objetivo deste estudo foi avaliar a produção de biomassa e estoque de nutrientes na serapilheira acumulada em plantios de quatro clones de eucalipto (AEC-2034 (*Eucalyptus camaldulensis* x *E. grandis*) x *E. urophylla*)), AEC-2111 (*E. urophylla* x (*E. camaldulensis* x *E. grandis*)), AEC-007 (*E. toreliana* x *E. citriodora*) e o AEC-0043 (*E. citriodora* x *E. toreliana*) aos quatro anos e meio, em sistema integrado de Lavoura-Pecuária-Floresta (ILPF), em Inaciolândia – Goiás. Para a coleta de serapilheira (folhas, galhos, casca e miscelânea) foi utilizado um gabarito de área de 0,0625 m². Foram coletadas 20 amostras de serapilheira aleatoriamente em cada clone, totalizando 80 amostras. Em laboratório, todo material foi processado através de secagem, pesagem e moagem para determinação de biomassa e análises de teor nutricional. O acúmulo na produção média total de serapilheira foi de 6,07 Mg ha^{-1} para o clone AEC-2034, 5,20 Mg ha^{-1} para o clone AEC-2111, 3,41 Mg ha^{-1} para o clone AEC-007 e 3,23 Mg ha^{-1} para o clone AEC-0043. O componente folha apresentou o maior acúmulo total de nutrientes em todos os clones. O nitrogênio (N) foi o elemento com maior estoque na serapilheira acumulada em todos os clones. O maior acúmulo de biomassa de serapilheira ocorreu no clone AEC-2034 e o componente mais representativo foi a folha. O clone AEC-2034 apresentou maior estoque de nutrientes na serapilheira e o clone AEC-0043 o menor estoque. O macronutriente com maior acúmulo nos componentes avaliados foi o nitrogênio (N) e o micronutriente foi o ferro (Fe). Com base no acúmulo de serapilheira e devolução de nutrientes, o clone mais indicado em sistema ILPF nessa região é o clone AEC-2034.

Palavras – chave: Sistema integrado de produção, Sustentabilidade, Ciclagem de nutrientes

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[2]Agronomic Engineer, M.Sc. Postgraduate Program in Agronomy at Federal University of Goiás, GO state, Brazil. E-mail: <amandapvelozo@gmail.com>
[3] Forest Engineer, Dr. Researcher at Embrapa Florestas - Brazilian Agricultural Research Corporation (Embrapa)-Crop, Livestock and Forest Integration Systems-Santo Antônio de Goiás/GO state, Brazil. E-mail: <abilio.pachecos@gmail.com>
[4] Forest Engineer, Dra. Professor at Federal University of Goiás, GO state, Brazil. E-mail: <fncalil@gmail.com>
[5] Biologist, Dr. Researcher at Federal Institute of Goiás, Goiás, GO state, Brazil. E-mail: <carlos.neto@ifg.edu.br>

Introduction

Forest litter is a very old concept, as it comprises the layer of debris that accumulates on the soil of forest ecosystems. By definition, it encompasses the agglomerate of organic matter that is found on the surface of the soil which is no longer linked to the plant of origin, and which is already in some decomposition stage (CARVALHO et al., 2019).

Litter represents an extraordinary correlation in the organic production-decomposition cycle, being essential for the ecosystem functioning. In addition to seeds of different species on the surface of soils and plant remains of a forest there are also nutrients, organic matter and microorganisms which are fundamental for the regeneration of fertility and biological activity of these soils (RODRIGUES et al., 2010).

Several biotic and abiotic factors influence litter production, such as: temperature, altitude, latitude, precipitation, vegetation type, successional stage, luminosity regimes, relief, deciduousness, water availability and soil characteristics. Depending on the particularities of each ecosystem, a certain factor may prevail over the others (FIGUEIREDO-FILHO et al., 2003). Kleinpaul et al. (2005) state that litter conservation in contact with the soil in the forest causes it to be reused in the nutrient cycle of the ecosystem through its decomposition and release of the constituent minerals for subsequent reabsorption by the plant roots. This ensures that in addition to the mutual relationships between soil-plant, forest-soil-microfauna relationships are also established, which makes it possible to explain the existence of forests in areas with low fertility soils.

The nutrition of a vegetation system is evaluated through several methods; however, correct sampling is of paramount importance for the success of nutritional studies. Nitrogen can be transferred from *Eucalyptus* spp. and other forest species through litter decomposition (leaves, thin branches, reproductive materials and roots, including root exudates) and subsequent release (FORRESTER et al., 2006). Godinho et al. (2014) report that as leaves, branches and roots are added to the litter and undergo decomposition, nutrients are released into the soil and in turn made available to plants.

The nutrient cycling process is related to maintaining the productive capacity of eucalyptus stands, in which the litter biomass accumulated on the soil represents a relevant source of nutrients. It is known that knowledge about this dynamic provides subsidies for planning actions aimed at forestry, especially with regard to fertilization management (SANTOS et al, 2014). In view of the above, this study aimed to evaluate the litter and its nutrient stock in a plantation of four eucalyptus clones in an integrated crop-livestock-forest system (CLFS) in Inaciolândia, Goiás state, Brazil.

Material and methods

Study site

The study was conducted on four eucalyptus clones in an integrated Crop-Livestock-Forest System (CLFS), with AEC-2034 ((*Eucalyptus camaldulensis* x *E. grandis*) x *E. urophylla*)), AEC-2111 (*E. urophylla* x (*E. camaldulensis* x *E. grandis*)), AEC-007 (*E. toreliana* x *E. citriodora*) and AEC-0043 (*E. citriodora* x *E. toreliana*), located at Fazenda Macaúba, in Inaciolândia, Goiás state, Brazil. The predominant climate in the region is Aw according to the Köppen-Geiger classification, consisting of a tropical climate with a dry winter season (CARDOSO et al., 2014). The average annual rainfall is 1,230 mm, concentrated in the rainy season from October to March, and the average annual temperature is 25.3°C. Oxisol with an “A” horizon predominate at Fazenda Macaúba, moderately and prominently with a very loamy and clayey texture. It also has a high aluminum content, low availability of macro and micro nutrients and reduced organic matter content, while the clay fraction is predominantly composed of kaolinite, goethite or gibbsite (EMBRAPA, 1999).

The area was used for soybean cultivation (*Glycine max* L.) under the conventional system until 2015. The integrated Crop-Livestock-Forest System (CLFS) was adopted on approximately 40 hectares in 2016. First, eucalyptus clones were implanted and later *Panicum maximum* cv. Tamani forage species intercropped with corn (*Zea mays* L.) (Santa Fé System) in order to establish the system. Then, four eucalyptus clones were planted separately, with AEC-2034 ((*Eucalyptus camaldulensis* x *E. grandis*) x *E. urophylla*)), AEC-2111 (*E. urophylla* x (*E. camaldulensis* x *E. grandis*)), AEC-007 (*E. toreliana* x *E. citriodora*) and AEC-0043 (*E. citriodora* x *E. toreliana*). Planting in rows was used for the spatial arrangement of the eucalyptus, each with four rows with a spacing of 3.0 m x 2.5 m. The distance used between rows was 22 m, totaling 485 trees ha^{-1}, meaning 33.3% of the area occupied by trees. The planting rows were oriented in the East-West direction to enable greater insolation to the crops intercropped between the lines.

Preventive control of termites was carried out in the entire area for planting eucalyptus clone seedlings. Ant control was performed throughout the seedling development. Then, furrowing (single-stem subsoiler) was carried out in the planting row at a depth of 60 cm, followed by the application of 300 kg ha^{-1} of Mono-Ammonium-Phosphate (MAP) in the formulation 11-52-00 (N - P_20_5 - K_20). Topdressing fertilization was conducted in May 2016 after seedling establishment with 120 g of 20-00-20 (N - P_20_5 - K_20) per plant. The corn was sown in November 2016 in the Santa Fé System, which comprises the cultivation of corn and Tamani (*Panicum maximum* cv. Tamani) sown together using a mechanized seeder for intercropping, with two corn rows spaced 0. 90 m and interspersed with grass spaced at 0.90 m.

Sowing was performed by keeping a minimum distance of 1.0 m from the eucalyptus in order to minimize the initial competition between the species. The fertilization at planting and coverage consisted of 350 kg ha^{-1} of formulated fertilizer 08-28-16 (N-P_20_5-K_20) and 200 kg ha^{-1} of urea at 45% N (parceled into two applications), respectively. All the necessary cultural and silvicultural treatments were carried out for each culture, respecting their respective technical recommendations. The eucalyptus was eight months old at the time of sowing corn and pasture, and had an average height of 2.5 m. Cattle were introduced into the integration system one year and two months after planting the eucalyptus. Soil analysis with soil fertility in the different clones is presented in Table 1.

Collection, preparation and compartmentalization of litter

A template with an area of 0.0625 m² was used for the litter collection, considered here as all material accumulated on the ground (leaves, branches, bark and miscellaneous) in different degrees of decomposition. A total of 20 litter samples were randomly collected from each clone (AEC-2034, AEC-2111, AEC-007 and AEC-0043), totaling 80 samples, following the methodology of Kleinpaul et al. (2003). The litter layer was collected at these sampling sites until the mineral soil was exposed. The collection was carried out in August 2020 during the dry season.

The collected samples were stored in Kraft paper bags, identified and sent to the Forest Ecology Laboratory of the Federal University of Goiás (UFG), where all collected material was placed in a circulation oven and air renewal for approximately 72 hours at 65°C until constant weight was reached in order to obtain the dry mass.

The samples were then manually separated with the aid of tweezers and weighed on a digital scale to determine the dry mass. The deposited litter was separated into four fractions: (a) leaves (L): litter fraction consisting of dry leaves and/or in a state of decomposition; b) branches/twigs/stems (Br): part of the litter consisting only of tree branches/twigs/stems; c) bark (Ba): part of the litter consisting only of bark; and d) miscellaneous (M): reproductive material, fruits, grass and other plant material, for which the origin could not be identified (GODINHO et al., 2013).

Table 1 - Physical and chemical soil analyzes performed in 2016 after planting eucalyptus clones (AEC-2034, AEC-2111, AEC-007 and AEC-0043) in the area of Fazenda Macaúba in the municipality of Inaciolândia, GO state, Brazil.

Tabela 1 - Análises físicas e químicas do solo realizadas em 2016 após o plantio de clones de eucalipto (AEC-2034, AEC-2111, AEC-007 e AEC-0043) na área da Fazenda Macaúba no município de Inaciolândia, GO, Brasil.

Clone	depth	OM	pH	P(Mehl)	K	S	Ca	Mg	Al	H+Al	K	CEC	m	V	Clay	Sand
	(cm)	g dm^{-3}	($CaCl_2$)	mg dm^{-3} (ppm)			cmolc dm^{-3} (mE 100ml)					cmolc dm^{-3}	%	%	(g kg^{-1})	
AEC 2034	0 - 10	40	5.0	28.4	315.6	4.2	5.6	1.7	0.0	2.6	0.8	10.7	-	75.7	440	460
	10 - 20	36	5.2	17.5	331.8	5.0	5.8	1.7	0.0	2.7	0.8	11	-	75.6	470	420
	20 - 40	29	5.2	6.7	199.7	2.8	4.3	0.8	0.0	1.8	0.5	7.4	-	75.7	480	410
AEC 2111	0 - 10	37	4.8	8.5	140.5	6.4	2.5	0.9	0.2	3.9	0.3	7.6	5.0	49.2	440	450
	10 - 20	30	4.8	8.8	132.5	2.5	2.0	0.8	0.2	2.6	0.3	5.7	5.9	54.8	570	320
	20 - 40	22	5.0	2.7	51.5	4.2	1.8	0.6	0.0	2.2	0.1	4.7	-	53.6	600	280
AEC 007	0 - 10	37	4.9	21.2	223.4	5.0	2.1	0.9	0.1	3.1	0.5	6.6	2.7	53.6	420	480
	10 - 20	28	4.7	10.4	138.3	4.2	1.4	0.6	0.2	2.6	0.3	4.9	7.8	47.6	460	430
	20 - 40	21	4.9	3.4	36.0	3.4	1.4	0.5	0.1	2.3	0.0	4.3	4.7	46.5	570	320
AEC 0043	0 - 10	40	5.0	23.7	214.1	6.4	3.0	1.2	0.1	3.2	0.5	7.9	2.0	59.9	440	460
	10 - 20	48	4.8	39.6	192.2	5.6	2.0	0.8	0.2	3.3	0.4	6.6	5.7	50.1	450	440
	20 - 40	30	5.1	10.8	70.7	4.2	3.0	0.7	0.0	3.1	0.1	7.0	-	55.7	470	420

*OM = organic matter.

The dry mass was used to calculate the total litter biomass per hectare. The estimate per unit area (hectare) was performed by extrapolating the dry mass based on the frame area (0.0625 m²) with the equation: Biomass = average weight (kg) x 10,000 / 0.0625.

Nutrient content and stock

After weighing, the litter samples were transformed into composite samples to be ground and sent to the laboratory to analyze the nutrient content. Next, 5 samples of each fraction were joined to make the composite samples, totaling 4 composite samples (leaves, branches, bark and miscellaneous) per clone. All material from the composite samples was ground in a Lippel crusher, then passed through a Wiley-type mill and passed through 1.0 mm (20 mesh) sieves. The material was subsequently sent for chemical analysis at the Laboratory of Foliar Analysis of the Federal University of Goiás to determine the macronutrient (N, P, K, Ca, Mg, S) and micronutrient (B, Cu, Fe, Mn, Zn) contents in plant tissue according to the methodology of Miyazawa et al. (1999).

Data analysis

The distribution of data residuals was verified for statistical analysis, and later the analysis of variance was performed using the non-parametric Kruskal-Wallis test at 95% significance comparing the litter biomass between the different clones (AEC-2034, AEC-2111, AEC-007 and AEC-0043). An analysis of variance was performed for the nutritional content analysis by comparing each element (nutrients) among the study clones with 95% significance. In addition, the product between the average nutrient content and the dry biomass of each compartment was used to estimate the total nutrient stock. Finally, a principal components analysis was carried out using a correlation matrix to verify the content and the nutritional stock in relation to the litter fractions of the clones.

Results

Litter biomass

It can be seen in Table 2 that the total litter biomass in the AEC-2034 clone is 6.07 Mg ha^{-1} and the relative distribution of the above ground litter components followed the descending order: leaves > branches > miscellaneous > bark. The total litter biomass for the AEC-2111 clone is 5.20 Mg ha^{-1} and the relative distribution of litter components followed the decreasing order: leaves > branches > bark > miscellaneous. Next, the total litter biomass in the AEC-007 clone is 3.41 Mg ha^{-1} and the relative distribution of litter components followed the decreasing order: leaves > branches > bark > miscellaneous. Finally, the total litter biomass in the AEC-0043 clone is 3.23 Mg ha^{-1} and the relative distribution of the above ground litter components followed the decreasing order: leaves > twigs > miscellaneous > bark.).

Table 2 - Biomass (mean ± standard deviation) of litter for AEC-2034, AEC-2111, AEC-007 and AEC-0043 clones under a CLFS system at Fazenda Macaúba, Inaciolândia, GO state, Brazil.
Tabela 2 - Biomassa (média ± desvio padrão) da serapilheira acumulada para os clones AEC-2034, AEC-2111, AEC-007 e AEC-0043 em sistema ILPF na Fazenda Macaúba, Inaciolândia, GO, Brasil.

Clone	Biomass				
	Leaves	Branches	Bark	Miscellaneous	Total
	kg ha^{-1}				
AEC-2034	3,650.69 ±1,483.3 (60. 09%)	2,090.03±1,361.2 (34.41%)	33.92 ± 60.1 (0.55%)	299.98 ±248.1 (4.9%)	6,074.62 ± 2,099.8
AEC-2111	2,498.17±1,299.7 (48.02%)	1.378.30 ±1.385.9 (26.49%)	997.46 ±1,373.8 (19.17%)	327.71±275.3 (6.3%)	5,201.66 ± 3,212.5
AEC-007	1,934.19 ±1,175.9 (56.58%)	1,090.17±1,387.5 (31.89%)	210.28 ± 364.3 (6.15%)	183.54 ±172.7 (5.37%)	3,418.18 ± 2,584.1
AEC-0043	2,202.42 ±1,046.2 (68.08%)	821.87±747.7 (25.40%)	70.07 ±174.5 (2.17%)	140.26 ±145.1 (4.3%)	3,234.62 ± 1,578.2

* Values in parentheses correspond to the percentage of each compartment.

Composition of the litter

The total litter biomass did not differ between AEC-2034 and AEC-2111 clones, which both showed greater litter accumulation in the soil compared to the AEC-007 and AEC-0043 clones. The AEC-2034 clone presented the highest amount of leaves in the litter per hectare. The AEC-2111, AEC-007 and AEC-0043 clones did not have significant differences between them in relation to the proportion of leaves (Figure 1).

The AEC-2034 clone had highest number of branches in the litter per hectare. The AEC-2111, AEC-007 and AEC-0043 clones presented statistically equal means among each other. The AEC-2111 clone presented the highest amount of bark in the litter per hectare. Moreover, AEC-2034, AEC-007 and AEC-0043 clones did not have significant differences between them. The AEC-0043 clone showed the lowest amount of miscellaneous litter per hectare. The AEC-2034, AEC-2111 and AEC-007 clones showed statistically equal means among each other (Figure 1).

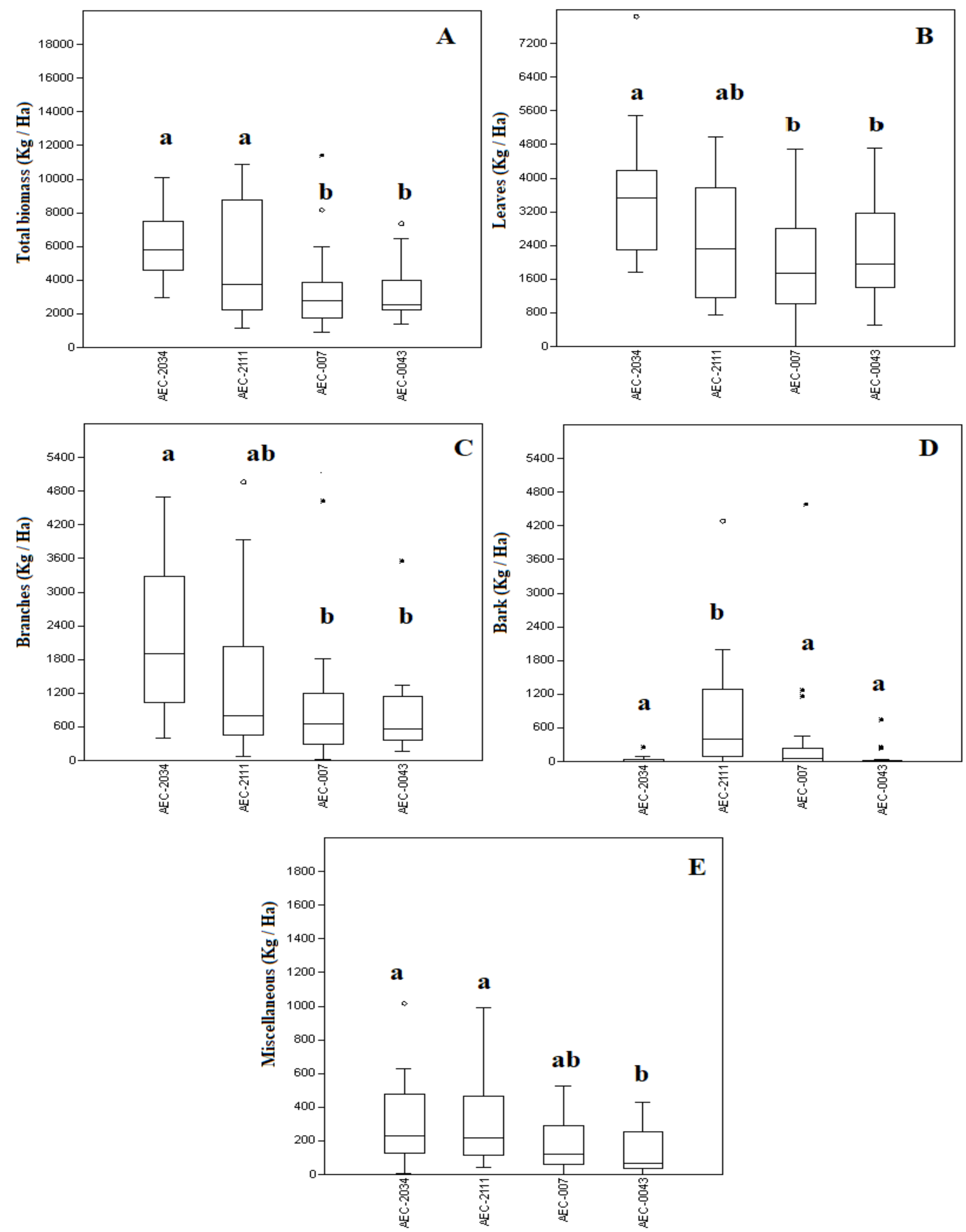

Figure 1 - Biomass of litter components (kg ha^{-1}) in AEC-2034, AEC-2111, AEC-007 and AEC-0043 clones under a CLFS at the Fazenda Macaúba, Inaciolândia, GO state, Brazil.

Figura 1 - Biomassa de componentes da serapilheira acumulada (kg ha^{-1}) nos clones AEC-2034, AEC-2111, AEC-007 e AEC-0043 em sistema ILPF na Fazenda Macaúba, Inaciolândia, GO, Brasil.

Nutrient content and stock in litter

The litter nutritional composition was different between each fraction, as evidenced in Tables 3 and 5 which show the content of the fractions referring to macronutrients and micronutrients. The leaf fraction had the highest amount of nutrients, with elements such as nitrogen (N), calcium (Ca), boron (B), magnesium (Mg), manganese (Mn) and iron (Fe). The branch fraction was the most similar component to the leaf, and the bark and miscellaneous fractions generally presented the lowest amount of nutrients.

Macronutrients

Nitrogen element (N) was present in greater amounts in all fractions in all clones (AEC-2034, AEC-2111, AEC-007 and AEC-0043). Calcium (Ca) was the second largest element in quantity in all clones. Sulfur (S) was the element which was present in the smallest amount in all clones.

The nitrogen element (N) does not differ between the bark, leaf and branch fractions when statistically compared between the four studied clones, while the AEC-2111 clone showed lower N content in miscellaneous fraction in relation to the other clones. Phosphorus (P) did not show differences between the clones in leaf, branch and miscellaneous fractions, while the AEC-2111 clone presented higher P content in bark fraction in relation to the other clones. Potassium (K) presented the highest content in bark fraction of AEC-2111 clone, while the other fractions showed no differences. Calcium (Ca) showed no significant difference between clones. Magnesium (Mg) showed no difference between the leaf, branch and miscellaneous fractions of the four clones, while the bark fraction showed higher content in the AEC-2111 clone. Sulfur (S) showed higher content in bark fraction of AEC-2111 clone in relation to the other clones (Table 3).

According to Table 4, variations in nutritional stock present in litter can be seen. Thus, it was possible to clearly observe that the nutrient stock in leaf fraction was higher for nitrogen (N), calcium (Ca), magnesium (Mg), sulfur (S).

As shown in Table 3, the AEC-2034 clone had the highest nitrogen (108.5261 kg ha^{-1}) and calcium (136.8262 kg ha^{-1}) stock in litter. The AEC-2111 clone had higher phosphorus (6.519 kg ha^{-1}), potassium (54.9974 kg ha^{-1}), magnesium (10.6208 kg ha^{-1}) and sulfur (7.5419 kg ha^{-1}) stocks. The AEC-007 and AEC-0043 clones generally showed lower macronutrient stock. The AEC-2034 clone had the highest macronutrient stock and AEC-0043 clone had the lowest stock.

Macronutrient stock generally followed the order: leaf > branch > bark > miscellaneous, while the magnitude of macronutrient storage generally had the following order: N > Ca > Mg > K > P > S (Table 6).

Micronutrients

In micronutrient content analysis, iron (Fe) element was present in greater amounts in all of the studied clones (AEC-2034, AEC-2111, AEC-007 and AEC-0043); in contrast, copper (Cu) occurred in smaller amounts (Table 5). Statistically compared, boron (B) did not show significant differences between clones (AEC-2034, AEC-2111, AEC-007 and AEC-0043). Copper (Cu) showed a significant difference in bark fraction, with AEC-0043 clone having the highest content in relation to the other clones. Iron (Fe) showed differences in bark and branch fractions of the study clones. Manganese (Mn) showed a difference in the leaf fraction, with the AEC-007 and AEC-0043 clones presenting higher contents. Lastly, zinc (Zn) showed a statistical difference in the leaf fraction, with the AEC-007 and AEC-0043 clones having higher contents.

The stock of micronutrients in litter fractions followed the order: leaf > branch > miscellaneous > bark, with the only exception of Fe, in which the order was changed to: leaf > branch > bark > miscellaneous. The magnitude of micronutrient storage had the following order: Fe > Mn > Zn > B > Cu (Table 6).

Table 3 - Mean concentration of macronutrients (mean ± standard deviation) in litter of the four studied clones (AEC-2034, AEC-2111, AEC-007 and AEC-0043) in an CLFS at the Fazenda Macaúba, Inaciolândia, GO, Brazil.
Tabela 3 - Concentração média de macronutrientes (média ± desvio padrão) na serapilheira acumulada dos quatro clones estudados (AEC-2034, AEC-2111, AEC-007 e AEC-0043) em um sistema ILPF na Fazenda Macaúba, Inaciolândia, GO, Brasil.

CLONE	FRACTION	N	P	K	Ca	Mg	S
		g kg^{-1}					
AEC-2034	Bark	12.43 ± 1.41a*	0.71 ± 0.37 a	1.8 ± 1.25 a	12.03 ± 0.47 a	1.41 ± 0.27 a	0.15 ± 0.01 a
	Leaf	22.16 ± 0.30a	0.58 ± 0.12 a	0.7 ± 0.12 a	32.78 ± 46.21 a	1.12 ± 0.01 a	0.75 ± 0.73 a
	Branch	8.91 ± 2.82a	0.84 ± 0.45a	8.4 ± 4.63a	6.27 ± 1.55a	1.35 ± 0.64a	0.18 ± 0.12a
	Miscellaneous	28.53 ± 13.97a	0.93 ± 0.14a	5.45 ± 4.46a	12.11 ± 5.18a	1.77 ± 0.52a	0.21 ± 0.08a
AEC-2111	Bark	8.35 ± 0.85a	2.89 ± 0.57b	24.75 ± 4.84b	13.12 ± 3.12a	3.47 ± 0.37b	3.24 ± 1.16b
	Leaf	20.27 ± 1.66a	0.51 ± 0.11a	3.5 ± 2.07a	9.782 ± 2.92a	1.29 ± 0.29a	0.30 ± 0.12a
	Branch	8.61 ± 3.02a	1.44 ± 0.97a	13.65 ± 10.12a	12.53 ± 2.92a	2.43 ± 1.12a	2.36 ± 2.53a
	Miscellaneous	16.10 ± 1.38b	1.06 ± 0.83a	8.4 ± 9.63a	8.38 ± 3.14a	1.715 ± 1.56a	0.84 ± 1.51a
AEC-007	Bark	20.12 ± 4.47a	0.44 ± 0.10a	2.53 ± 1.79ac	10.66 ± 0.58a	1.39 ± 0.24a	0.17 ± 0.11a
	Leaf	23.02 ± 1.71a	0.57 ± 0.28a	2.4 ± 0.99a	15.60 ± 15.18a	1.41 ± 0.14a	0.33 ± 0.18a
	Branch	11.22 ± 0.42a	0.52 ± 0.10a	2.75 ± 0.75a	10.43 ± 1.74a	1.43 ± 0.26a	0.20 ± 0.09a
	Miscellaneous	20.85 ± 0.89a	0.70 ± 0.31a	4.55 ± 2.35a	9.06 ± 2.38 a	1.44 ± 0.39 a	0.30 ± 0.13 a
AEC-0043	Bark	16.95 ± 1.60a	0.53 ± 0.19a	1.6 ± 0.28ac	9.5 ± 1.98a	0.96 ± 0.27a	0.09 ± 0a
	Leaf	15.07 ± 4.87a	0.69 ± 0.09a	2.4 ± 0.98 a	5.17 ± 0.89a	0.98 ± 0.42a	0.86 ± 0.21a
	Branch	8.89 ± 3.33a	0.56 ± 0.08a	4.85 ± 0.19a	10.77 ± 0.64a	0.93 ± 0.09a	0.32 ± 0.19a
	Miscellaneous	20.48 ± 0.67a	0.36 ± 0.04a	1.65 ± 0.41a	8.12 ± 3.10a	1.34 ± 0.20a	0.09 ± 0.05a

* Means followed by the same letter in the column do not differ by analysis of variance with 95% significance.

Table 4 - Macronutrient stock (mean ± standard deviation) in litter of the four studied clones (AEC-2034, ACE-2111, AEC-007 and AEC-0043) in a CLFS at the Fazenda Macaúba, Inaciolândia, GO state, Brazil.
Tabela 4 - Estoque de macronutrientes (média ± desvio padrão) na serapilheira acumulada dos quatro clones estudados (AEC-2034, ACE-2111, AEC-007 e AEC-0043) em um sistema ILPF na Fazenda Macaúba, Inaciolândia, GO, Brasil.

CLONE	**FRACTION**	**N**	**P**	**K**	**Ca**	**Mg**	**S**
		kg ha^{-1}					
AEC-2034	Bark	0.42 ± 0.047	0.02 ± 0.012	0.06 ± 0.042	0.41 ± 0.016	0.05 ± 0.009	0.01 ± 0
	Leaf	80.91 ± 1.083	2.14 ± 0.449	2.56 ± 0.421	119.68 ± 168.712	4.09 ± 0.051	2.77 ± 2.675
	Branch	18.64 ± 5.888	1.77 ± 0.935	17.56 ± 9.677	13.1 ± 3.247	2.82 ± 1.330	0.38 ± 0.259
	Miscellaneous	8.56 ± 4.192	0.28 ± 0.041	1.63 ± 1.339	3.64 ± 1.553	0.53 ± 0.154	0.07 ± 0.024
TOTAL		**108.53**	**4.22**	**21.81**	**136.83**	**7.49**	**3.22**
AEC-2111	Bark	8.34 ± 0.852	2.89 ± 0.571	24.69 ± 4.827	13.09 ± 3.110	3.46 ± 0.369	3.23 ± 1.153
	Leaf	50.64 ± 4.153	1.29 ± 0.274	8.74 ± 5.168	24.44 ± 7.307	3.24 ± 0.718	0.77 ± 0.302
	Branch	11.88 ± 4.166	1.99 ± 1.342	18.81 ± 13.944	17.28 ± 4.031	3.36 ± 1.544	3.26 ± 3.486
	Miscellaneous	5.28 ± 0.452	0.35 ± 0.272	2.75 ± 3.155	2.75 ± 1.029	0.56 ± 0.510	0.28 ± 0.494
TOTAL		**76.14**	**6.52**	**55**	**57.55**	**10.62**	**7.54**
AEC-007	Bark	4.23 ± 0.940	0.09 ± 0.021	0.53 ± 0.376	2.24 ± 0.121	0.29 ± 0.050	0.04 ± 0.024
	Leaf	44.53 ± 3.298	1.11 ± 0.542	4.64 ± 1.921	30.18 ± 29.353	2.73 ± 0.274	0.64 ± 0.349
	Branch	12.24 ± 0.459	0.58 ± 0.113	3 ± 0.823	11.37 ± 1.891	1.57 ± 0.285	0.22 ± 0.093
	Miscellaneous	3.83 ± 0.163	0.13 ± 0.056	0.84 ± 0.430	1.66 ± 0.437	0.26 ± 0.071	0.06 ± 0.023
TOTAL		**64.83**	**1.91**	**9.01**	**45.46**	**4.85**	**0.96**
AEC-0043	Bark	1.19 ± 0.112	0.04 ± 0.013	0.11 ± 0.019	0.67 ± 0.138	0.07 ± 0.018	0.01 ± 0
	Leaf	33.21 ± 10.716	1.54 ± 0.198	5.29 ± 2.157	11.4 ± 1.969	2.17 ± 0.920	1.9 ± 0.457
	Branch	7.31 ± 2.738	0.47 ± 0.066	3.99 ± 0.157	8.86 ± 0.530	0.77 ± 0.076	0.26 ± 0.157
	Miscellaneous	2.87 ± 0.094	0.05 ± 0.005	0.23 ± 0.057	1.14 ± 0.434	0.19 ± 0.028	0.01 ± 0.006
TOTAL		**44.58**	**2.09**	**9.62**	**22.06**	**3.2**	**2.18**

Table 5. Mean concentration of micronutrients (mean ± standard deviation) in litter of the four studied clones (AEC-2034, AEC-2111, AEC-007 and AEC-0043) in a CLFS at the Fazenda Macaúba, Inaciolândia, GO state, Brazil.
Tabela 5 – Concentração média de micronutrientes (média ± desvio padrão) na serapilheira acumulada dos quatro clones estudados (AEC-2034, AEC-2111, AEC-007 e AEC-0043) em um sistema ILPF na Fazenda Macaúba, Inaciolândia, GO, Brasil.

CLONE	FRACTION	B	Cu	Fe	Mn	Zn
		mg kg^{-1}				
AEC-2034	Bark	19.06 ± 5.74 a*	3.40 ± 4.17 ab	2,090.00 ± 640.86 c	113.4 ± 41.92 a	15.16 ± 8.52 a
	Leaf	29.80 ± 2.72 a	6.91 ± 2.46 a	2,517.50 ± 429.06 a	227.75 ± 47.88 a	19.67 ± 2.18 a
	Branch	6.95 ± 0.92 a	8.55 ± 4.68 a	1,552.50 ± 620.56 bc	154.25 ± 21.59 a	17.46 ± 4.58 a
	Miscellaneous	20.20 ± 2.35 a	10.05 ± 3.07 a	2,487.50 ± 145.23 a	170.25 ± 50.78 a	27.60 ± 3.88 a
AEC-2111	Bark	8.84 ± 2.31 a	4.04 ± 3.76 ab	1,820.00 ± 759.39 bc	304.25 ± 313.69 a	3.31 ± 2.59 a
	Leaf	27.52 ± 1.99 a	9.19 ± 3.60 a	1,800.00 ± 579.83 a	475.75 ± 76.29 a	12.11 ± 4.51 a
	Branch	7.08 ± 1.44 a	5.02 ± 3.31 a	1,233.50 ± 519.23 bc	219.25 ± 67.20 a	6.50 ± 1.79 a
	Miscellaneous	15.5523 ± 6.20 a	9.48 ± 1.79 a	2,582.50 ± 314.15 a	288.25 ± 75.82 a	22.46 ± 6.20 a
AEC-007	Bark	14.09 ± 2.08 a	10.52 ± 0.88 bc	3,023.33 ± 132.79 abc	448.33 ± 174.06 a	28.44 ± 9.63 a
	Leaf	21.03 ± 2.48 a	11.26 ± 3.47 a	2,672.50 ± 198.56 a	901.25 ± 34.18 b	51.92 ± 4.53 b
	Branch	8.71 ± 1.98 a	9.04 ± 3.21 a	2,505.00 ± 758.71 a	318 ± 48.91 a	32.70 ± 27.48 a
	Miscellaneous	17.13 ± 8.53 a	18.74 ± 6.19 a	3,225.00 ± 134.78 a	443.5 ± 49.96 a	43.32 ± 13.25 a
AEC-0043	Bark	11.95 ± 4.84 a	22.1 ± 13.53 c	3,435.00 ± 205.06 a	423.5 ± 24.75 a	35.99 ± 11.45 a
	Leaf	21.82 ± 1.63 a	4.39 ± 3.91 a	2,020.00 ± 369.23 a	799 ± 160.91 b	51.86 ± 13.66 b
	Branch	7.39 ± 4.75 a	5.52 ± 3.96 a	1,802.50 ± 507.11 abc	206.75 ± 32.56 a	11.60 ± 2.10 a
	Miscellaneous	21.12 ± 5.25 a	10.22 ± 2.54 a	2,870.00 ± 291.78 a	350.25 ± 152.47 a	30.45 ± 15.12 a

* Means followed by the same letter in the column do not differ by analysis of variance with 95% significance.

Table 6 - Micronutrient stock (mean ± standard deviation) in litter of the four studied clones (AEC-2034, ACE-2111, AEC-007 and AEC-0043) in a CLFS at the Fazenda Macaúba, Inaciolândia, GO state, Brazil.

Tabela 6 - Estoque de micronutrientes (média ± desvio padrão) na serapilheira acumulada dos quatro clones estudados (AEC-2034, ACE-2111, AEC-007 e AEC-0043) em um sistema ILPF na Fazenda Macaúba, Inaciolândia, GO, Brasil.

CLONE	FRACTION	B	Cu	Fe	Mn	Zn
				kg ha^{-1}		
AEC-2034	Bark	0.0006 ± 0	0.0001 ± 0	0.0709 ± 0.021	0.0038 ± 0.001	0.0005 ± 0
	Leaf	0.1088 ± 0.009	0.0252 ± 0.009	9.1906 ± 1.566	0.8314 ± 0.174	0.0718 ± 0.008
	Branch	0.0145 ± 0.001	0.0179 ± 0.009	3.2448 ± 1.297	0.3224 ± 0.045	0.0365 ± 0.009
	Miscellaneous	0.0061 ± 0	0.003 ± 0	0.7462 ± 0.043	0.0511 ± 0.015	0.0083 ± 0.001
TOTAL		**0.13**	**0.0462**	**13.2524**	**1.2087**	**0.1171**
AEC-2111	Bark	0.0088 ± 0.002	0.004 ± 0.003	1.8154 ± 0.757	0.3035 ± 0.312	0.0033 ± 0.002
	Leaf	0.0688 ± 0.005	0.023 ± 0.009	4.4967 ± 1.448	1.1885 ± 0.190	0.0303 ± 0.011
	Branch	0.0098 ± 0.002	0.0069 ± 0.004	1.7001 ± 0.715	0.3022 ± 0.092	0.009 ± 0.002
	Miscellaneous	0.0051 ± 0.002	0.0031 ± 0	0.8463 ± 0.103	0.0945 ± 0.024	0.0074 ± 0.002
TOTAL		**0.0924**	**0.037**	**8.8585**	**1.8886**	**0.4989**
AEC-007	Bark	0.003 ± 0	0.0022 ± 0	0.6357 ± 0.027	0.0943 ± 0.036	0.006 ± 0.002
	Leaf	0.0407 ± 0.004	0.0218 ± 0.006	5.1691 ± 0.384	1.7432 ± 0.066	0.1004 ± 0.008
	Branch	0.0095 ± 0.002	0.0099 ± 0.003	2.7309 ± 0.827	0.3467 ± 0.053	0.0357 ± 0.030
	Miscellaneous	0.0031 ± 0.001	0.0034 ± 0.001	0.5919 ± 0.827	0.0814 ± 0.009	0.008 ± 0.002
TOTAL		**0.0562**	**0.0372**	**9.1276**	**2.2654**	**0.15**
AEC-0043	Bark	0.0008 ± 0	0.0015 ± 0	0.2407 ± 0.014	0.0297 ± 0.001	0.0025 ± 0
	Leaf	0.0481 ± 0.003	0.0097 ± 0.008	4.4489 ± 0.813	1.7597 ± 0.354	0.1142 ± 0.030
	Branch	0.0061 ± 0.003	0.0045 ± 0.003	1.4814 ± 0.416	0.1699 ± 0.026	0.0095 ± 0.001
	Miscellaneous	0.003 ± 0	0.0014 ± 0	0.4025 ± 0.040	0.0491 ± 0.021	0.0043 ± 0.002
TOTAL		**0.0579**	**0.0171**	**6.5735**	**2.0084**	**0.1305**

The data in Table 6 corresponds to the stock of micronutrients, and revealed that the leaf component represented the highest stock. The element with the greatest accumulation in the evaluation of the components was iron.

As shown in Table 6, the AEC-2034 clone had the highest boron (0.13 kg ha^{-1}), copper (0.0462 kg ha^{-1}) and iron (13.2524 kg ha^{-1}) stock in litter total. The AEC-2111 clone had the highest zinc stock (0.4989 kg ha^{-1}), while the AEC-007 clone had the highest manganese stock (2.2654 kg ha^{-1}). The AEC-2034 clone generally had the highest stock of micronutrients, and the AEC-0043 clone had the lowest stock.

Nutrient storage magnitude

Next, the magnitude gradient of macro and micronutrient storage in the fractions was elaborated from the analysis of nutrient stocks in litter for the four study clones (Table 7).

Table 7- Nutrient storage magnitude gradient in litter for the four studied clones (AEC-2034, ACE-2111, AEC-007 and AEC-0043) at the Fazenda Macaúba, Inaciolândia, GO state, Brazil.

Tabela 7 - Gradiente de magnitude de armazenamento de nutrientes em serapilheira acumulada para os quatro clones estudados (AEC-2034, ACE-2111, AEC-007 e AEC-0043) na Fazenda Macaúba, Inaciolândia, GO, Brasil.

Clone	Fraction	Macronutrients	Micronutrients
AEC-2034	Bark	N > Ca > K > Mg > P > S	Fe > Mn > B > Zn > Cu
	Leaf	N > Ca > Mg > S > K > P	Fe > Mn > B > Zn > Cu
	Branch	N > K > Ca > Mg > P > S	Fe > Mn > Zn > Cu > B
	Miscellaneous	N > Ca > K > Mg > P > S	Fe > Mn > Zn > B > Cu
AEC-2111	Bark	K > Ca > N > Mg > S > P	Fe > Mn > B > Cu > Zn
	Leaf	N > Ca > K > Mg > P > S	Fe > Mn > B > Zn > Cu
	Branch	K > Ca > N > Mg > S > P	Fe > Mn > B > Zn > Cu
	Miscellaneous	N > K > Ca > Mg > P > S	Fe > Mn > Zn > B > Cu
AEC-007	Bark	N > Ca > K > Mg > P > S	Fe > Mn > Zn > B > Cu
	Leaf	N > Ca > K > Mg > P > S	Fe > Mn > Zn > B > Cu
	Branch	N > Ca > K > Mg > P > S	Fe > Mn > Zn > Cu > B
	Miscellaneous	N > Ca > K > Mg > P > S	Fe > Mn > Zn > Cu > B
AEC-0043	Bark	N > Ca > K > Mg > P > S	Fe > Mn > Zn > Cu > B
	Leaf	N > Ca > K > Mg > S > P	Fe > Mn > B > Zn > Cu
	Branch	Ca > N > K > Mg > P > S	Fe > Mn > Zn > B > Cu
	Miscellaneous	N > Ca > K > Mg > P > S	Fe > Mn > Zn > B > Cu

Discussion

It is possible to notice that the leaf component presented higher biomass in all clones (58.19%). The branch component presented the second highest biomass in all clones. The bark and miscellaneous fractions varied among the clones. In a study of litter in eucalyptus stands planted at 12 years of age in the municipality of Santa Maria/RS state, Brazil, Kleinpaul et al. (2003) found 11.63 Mg ha^{-1}, with the branch fraction predominating with 39% (4.53 Mg ha^{-1}) followed by leaf fractions with 36.2%, bark with 12.1%, miscellaneous with 9.5%, and reproductive structures with 3.4%. The higher percentage presented by the branches can be explained by the fact that the stand was already in its adult stage and natural pruning occurs.

In a study on nutrient cycling in a one-and-a-half-year-old *Eucalyptus dunnii* stand in the Pampa biome, Corrêa (2011) obtained a deposition of approximately 4.1 Mg ha^{-1} $year^{-1}$ of litter, with an average of 93% leaves, 6% miscellaneous, and 1% thick branches. The miscellaneous fraction was composed of reproductive material, thin branches and bark.

According to Poggiani & Schumacher (2000), litter deposition increases until the trees reach maturity when the crowns close. After this phase, a slight decrease or stability in litter deposition is observed. We emphasize that both studies presented above as a comparison for eucalyptus and pine are homogeneous plantations, whereas our study was with the CLFS system, which may contribute to some differences found such as the different percentages of leaves, since the trees individually receive greater insolation in this system than in a homogeneous system, thus being able to invest in greater canopy growth. Caldeira et al. (2008) conceive that the species composition varies in the amount of litter on the soil, in addition to the influence of the successional stage, the extent of forest cover, age, collection time, forest type and location. Godinho et al. (2014) also add that other factors such as soil and climate conditions, understory, canopy proportion, silvicultural management, as well as the decomposition percentage and natural disturbances, such as insect/pest attacks and fire or even artificial ones, such as litter removal and crops occurring in the forest or in the stand can all also influence litter accumulation.

The values found in the present study are similar to the results obtained by Neto et al. (2001), who quantified the litter in the soil in a 40-year-old *Eucalyptus grandis* stand in Seropédica, RJ state, Brazil. These authors reported that the leaf fraction predominated in 53.3% in the deposition of materials that formed the litter. In a study carried out by Lima et al. (2015) in a five-year-old *Eucalyptus urograndis* stand located in the municipality of Goianápolis, GO state, Brazil, where the soil is classified as Oxisol, the result found was similar to the results of this study. The authors reported that most of litter is composed of leaves.

In a study carried out in a *Eucalyptus* spp. stand, Kleinpaul et al. (2005) observed greater accumulation of branches on the ground, with 38.8%. The authors state that eucalyptus stands characteristically suffer a more intense natural pruning process in relation to other species, and this leads to high deposition of branches on the soil. Carvalho et al. (2014) found the miscellaneous fraction as the main contributor to the formation of litter, overcoming leaves and branches, in a 5-year-old *Eucalyptus saligna* stand in Rio Grande do Sul state, Brazil. The authors explain that one of the relevant factors for the low amount of leaves deposited in the soil is linked to the collection periods being carried out in winter, with the highest production of leaves occurring in two distinct periods: early summer (November) and autumn (May), which demonstrates the heterogeneity in its distribution over the forest floor.

Few studies of litter in CLFS systems in the Cerrado have been carried out to date for valid comparisons between agroecosystems to be conducted. In one of the most recent CLFS studies for the Cerrado, Abreu et al. (2021) demonstrated that a CLFS system with *E. urograndis* had the highest litter accumulation at four years of age, with the same macronutrient contents. In studies with an integrated system with native trees from the Cerrado, Calil et al. (2016) highlighted that the baru (*Dipterix alata*) presented about 7.67 Mg ha^{-1} of litter biomass, whereas cagaiteira (*Eugenia dysenterica*) presented about 4.63 Mg ha^{-1}, and the pequi tree (*Caryocar brasiliense*) a total of 4.07 Mg ha^{-1}.

Several studies on litter deposition and accumulation in fast-growing forest plantations and in naturally regenerating stands are dominated by a single species. Production initially increases with age until it reaches a limit, in which the deposition growth rate, age and maximum deposition value are specific to each case. After reaching a certain threshold, the production value stabilizes or falls slowly (for long-lived species) or rapidly (for short-lived species). The concentrations of macronutrients in the total biomass are in the following order: leaf > branch > miscellaneous; this order was also found by Corrêa et al. (2013), who evaluated nutrient cycling in *Eucalyptus dunnii* planting, but only considered thick branches. In study with *Eucalyptus* spp. by Viera et al. (2012), the storage magnitude of the different elements in the total biomass presented the following decreasing order of accumulation for the macronutrients: Ca > N > K > Mg > P > S. A similar result was found in this study, with only the order of Ca > No differentiating.

According to Poggiani (2012), the material from the fall of tree canopy components, such as leaves, branches, fruits and flowers which are part of the litter production is responsible for 60% of the nutrient transfer to the soil. Leaves have higher metabolic activity, so there is a tendency for most nutrients to concentrate in the youngest structures of the plant (VIERA et al. 2012). The nitrogen content being much higher in the leaves compared to the other components is due to the fact that this element participates in most of the metabolism reactions of compounds (amino acids, proteins, amines, amides, vitamins, among others), because of the fact that photosynthesis has its main occurrence site in the leaves (MALAVOLTA, 1985). The same result was also observed in the studies by Bertalot et al. (2004) on leaf litter in a plantation with leguminous tree species, and Balieiro et al. (2004) in *Pseudosamanea guachapele* and *Eucalyptus grandis* plantations.

In a study of a five-year-old *Eucalyptus* stand in the city of Goianápolis, GO state, Brazil, Carvalho et al. (2019) found that the highest nitrogen content occurs in the leaf fraction when compared to the other litter fractions. A similar result was found in this study. Here we emphasize that even though there are differences between the system in the structure of homogeneous forest plantations and CLFS, no difference was observed in the nutritional profile of the leaves in the two systems. In the same study by Abreu et al. (2020), the element found in the highest concentrations was Ca, followed by N. The highest content found regarding micronutrients was for Fe, followed by Mn. In a study by Ferreira et al. (2021) for CLFS also in the Cerrado with *E. urograndis*, the concentration gradient of total nutritional contents was S > P > Mg > Ca > N > K for macronutrients and B > Cu > Zn > Fe > Mn for micronutrients.

According to Haag (1985) based on a compilation of several studies, the highest N concentration in relation to Ca is found in most studies with different forest formations. Calcium has the characteristic of low mobility within the plant and is slowly distributed to the components when the leaves are in senescence, thus conditioning higher foliar Ca levels in the leaf fraction (VITTI et al., 2006). In this study, calcium was the second element found in higher concentrations in litter. According to Corrêa et al. (2013), in a study on litter deposition and macronutrient concentrations in a *Eucalyptus dunnii* stand in the Pampa biome, there are higher concentrations of calcium in the leaves of the litter produced when compared to other fractions.

In a study of litter in a permanent preservation area, Cerrado *sensu stricto* and *Eucalyptus* and *Pinus* stands in the state of Goiás, Carvalho et al. (2019) found the following order of micronutrient contents: Fe, Mn, Zn and Cu. The same order was found in this study. The order of micronutrient concentration in the litter fractions was different from that found by Silva et al. (1983) for leaf analysis in living tissue. These authors found the order: Mn > Fe > Cu > Zn for *Eucalyptus dunnii*, *Eucalyptus saligna* and *Eucalyptus grandis*, planted in sandy soil with low fertility in Itirapina, SP state, Brazil, at 10 years of age.

Manganese was stored in greater amounts in the leaves, as it is a nutrient which is regularly found in the soil in the form of manganese oxides and sulfides. This nutrient accumulates in different parts of the plant and the allocation varies according to the vegetative period, with older leaves having a higher Mn concentration and young leaves having a lower accumulation (DECHEN and NACHTIGALL, 2006). Carvalho (2014) already demonstrated the high accumulation of Mn in the biomass of *E. urograndis*, being superior to Fe > B > Zn > Cu. The authors reinforce the accumulation of this nutrient through the retranslocation process, which involves the translocation of the nutrient between different parts of the plant, such as from a leaf to a new structure.

In studies with *Eucalyptus* spp., Viera et al. (2012) studied the storage magnitude of the different elements in the total biomass and presented the following decreasing order of accumulation for the micronutrients: Mn > Fe > B > Zn > Cu. There was no similarity in the order of any micronutrient in the results of this study. In the study by Calil et al. (2014) with a silvopastoral system, there was a result with similarity in micronutrients, being: Fe > Mn > Zn > B > Cu.

Conclusions

The AEC-2034 clone presented the highest biomass stock and nutritional content of litter. The AEC-0043 clone presented the lowest values for the same characteristics. The magnitude of the biomass accumulation was found to be in decreasing order as: leaf > branch > bark > miscellaneous, with bark and miscellaneous varying between clones. The general storage magnitude of macronutrients had the following order: N > Ca > K > Mg > P > S, while for micronutrients it followed: Fe > Mn > Zn > B > Cu.

Based on litter accumulation and nutrient return, the most suitable eucalyptus clone in the integrated CLFS in this region is the AEC-2034 clone. The integrated CLFS presented similar results of litter biomass and nutritional stock to those found for homogeneous eucalyptus plantations in the Cerrado, indicating that the model maintains the beneficial characteristics for the environment, returning biomass and providing nutrients in the system.

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